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CONTENTS

Original Papers:

Clay Sewer Pipe Manufacture—Schurecht 615
Capping for Compression Specimens—Foster 623
Some Notes on the Measurement of Translucency of Ceramic Bodies—Parmelee and Lowrance 630
The Effect of Some Substitutes for Tin Oxide on the Opacity of White Enamels for Sheet Steel—Danielson and Frehafer 634
The Reversible Thermal Expansion of Refractory Materials—Houldsworth and Cobb 645
Refractory Possibilities of Some Georgia Clays—Stull and Bole 663
Glass Wool Heat Insulation in Europe—Saborsky 674
Copper Reds for the Amateur—Cox 685

Ceramic Abstracts 89

The Bulletin:

Editorial 99
Zirconia in Sheet Iron Enamels—Wenning 102
Pricing and Costing Graded Product (with Discussion)—Webster 104
Notes on Burning Refractories with Special Reference to the Control of Labor Costs—Hewitt 109
Discussion on "The American Interest in Chinese Art" 117
Discussion on "Causes of Bulges on Struck-off Fire Clay Shapes" 119
Discussion on the "Meaning and Microscopic Measurement of Average Particle Size" 121
The Ceramic Engineering Department of the University of Washington, Seattle, Washington—Wilson 125
President's Page 130
Activities of the Society 131
Notes and News 138

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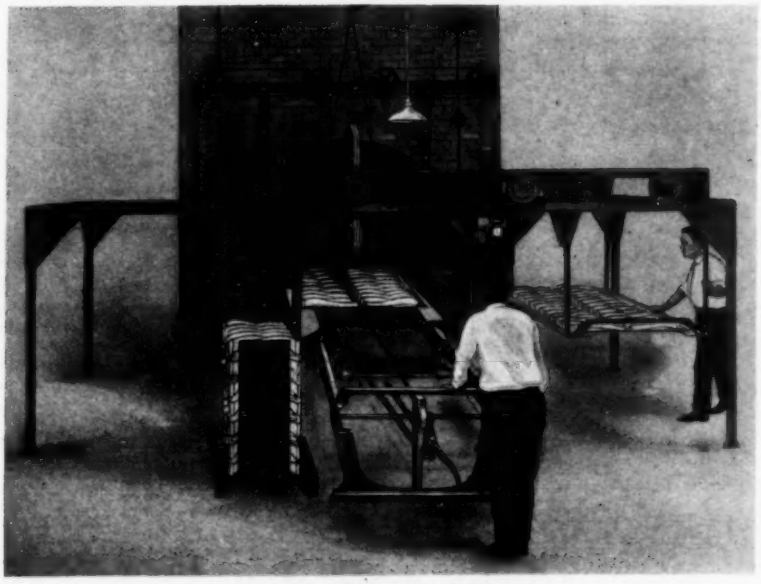

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ORIGINAL PAPERS

CLAY SEWER PIPE MANUFACTURE

I.—The Magnetic Separation of Iron Bearing Minerals from Clays[1]

By H. G. Schurecht[2]

ABSTRACT

Purpose.—Experiments were conducted to remove coarse iron bearing minerals from clays magnetically in order to prevent their formation of black blisters on sewer pipe.

Results.—It was found that most of the coarse iron bearing minerals can be removed by means of a high intensity magnetic separator. Although the cost of this treatment on the roasted clays is too great, the separation from the raw material is not prohibitive to plants suffering large losses due to this defect.

Introduction[3]

The requirements for sewer pipe are very rigid since they must not only be strong but also resistant to chemicals. At present sewer pipe made

[1] Published through the courtesy of The Easter Clay Products Association and The Clay Products Association under whose auspices this work has been conducted as a part of their research program on the manufacture of clay sewer pipe.

This is the first of a series of papers on this subject to appear in this *Journal.*

[2] Industrial Fellow, The Mellon Institute of Industrial Research, University of Pittsburgh, Pittsburgh, Pa.

[3] The writer wishes to acknowledge his indebtedness to Dr. E. W. Tillotson, Assistant Director of The Mellon Institute, for helpful advice during the progress of the work and to the Magnetic Separator companies for their coöperation in this work.

of clay is the only kind which meets the most important of these requirements. New specifications for sewer pipe are being made from time to time and in order to keep pace with these, this research is being conducted to improve the quality of clay sewer pipe. The possible methods of removing iron bearing minerals from clays are being investigated as a part of this program. Coarse particles of iron bearing minerals and clay particles containing a high content of iron oxide cause rough, black blisters on the glazed ware. The removal of particles causing these would not only improve the quality but also reduce the losses in their manufacture.

The most important of the iron bearing minerals producing this roughness are siderite, hematite, limonite, marcasite and pyrites.

Siderite, $FeCO_3$, is by far the most abundant of these in sewer pipe clays. It often occurs in bands in clay banks or as nodules, mixed with or

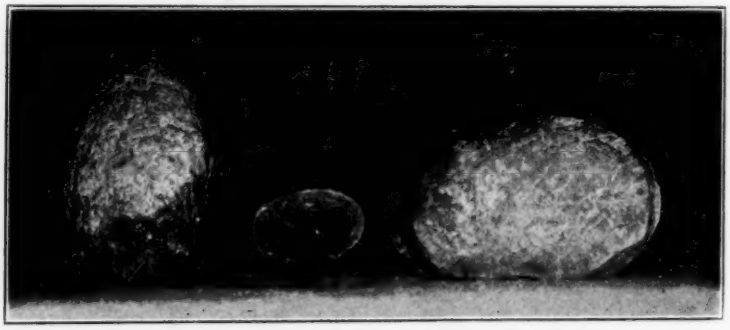

FIG. 1.—Nodules of siderite as they occur in clays.

without clay, which are commonly known as "kidney balls," see Fig. 1. The size of these nodules may vary from about one foot to $^1/_{16}$ inch in diameter.

Pyrite, FeS_2, usually crystallizes in the form of cubes and has a brass yellow color. Marcasite has the same composition as pyrites but forms different crystals, has a paler color and decomposes easier.

Limonite, $2Fe_2O_3.2H_2O$, and hematite, Fe_2O_3, are usually present in a fine-grained state mixed with the clays. They are often decomposition products of siderite, marcasite and pyrites.

Since most iron bearing minerals are magnetic to a certain degree and since clay particles containing an excess of certain iron bearing minerals are also magnetic, the separation of these by this method seemed worthy of investigation. A study was therefore made of this subject which has progressed far enough to show that the major portion of the coarse iron bearing minerals and clay particles containing too much iron oxide may be removed with a high intensity magnetic separator.

The Magnetic Properties of Some Iron Bearing Minerals

Generally speaking the magnetic susceptibility of the various iron bearing minerals as they occur in clays, decrease in the following order:[1]

Magnetite.—This mineral is very magnetic being about 65 per cent that of tempered steel and may be separated with a low intensity magnet.

Siderite.—Siderite is slightly magnetic, being about 0.1 per cent that of tempered steel and may be removed with a high intensity magnet.

Hematite.—This mineral is feebly magnetic and may be separated with a high intensity magnet.

Limonite.—Limonite is feebly magnetic and may be removed with a high intensity magnet.

Marcasite and Pyrites.—These minerals are usually non-magnetic, although sometimes they are feebly magnetic and in these cases can be separated with a high intensity magnet. They, however, become manetic if slightly roasted and may then be removed with a low intensity magnet.

As a rule coarse grains of magnetic substances may be more easily removed than fine grains of this material, since fine grains usually have a larger percentage of non-magnetic material adhering to them and hence a greater magnetic force would be necessary to remove them.

Operation of Some Magnetic Separators

A Low Intensity Magnetic Separator.—This separator is used for removing highly magnetic substances from granular material. It cannot be employed for separating the commoner iron bearing minerals from raw clays although it may be used for removing iron bearing minerals from roasted clay.

The magnet consists of a large stationary primary magnet body and a series of small secondary induced magnets mounted upon a rotating disk. The primary magnet is held solidly in a fixed position and has heavy double coils and cores with pole pieces projecting downward and conforming to the circle of the disk. The secondary magnets are inductively energized by the primary magnets when over the clay on a conveyor, but become demagnetized as they leave the proximity of the primary poles and automatically discharge any iron or magnetic material they may have attracted, allowing it to drop at the points on the sides where the disk overhangs the conveyor. The magnetic material is conveyed by chutes into a box or receptacle. The non-magnetic material passes off at the end of the conveyor to final delivery.

High Intensity Magnetic Separator (Type A).—The high intensity magnetic separator, type A, can be used for removing the commoner iron bearing minerals from clays.

[1] C. Godfrey Gunther, "Electro-Magnetic Ore Separation," Hill Publishing Co., N. Y. (1909).

The dry material to be treated drops from the hopper onto the feed roller, which spreads it in a thin uniform layer over the whole width of the conveyor belt, as it travels towards the poles of the magnetic system. The poles consist of two horseshoe electro-magnets, arranged one above the other. The poles of the upper magnet are forged in the form of a short wedge while the lower ones are flattened. This principal is characterized as "sharp against flat," and it is the high magnetic concentration on the upper pole, caused by the conveying field, which enables this separator to treat very weakly magnetic materials. The magnetic force of the upper wedge-shaped pole superceded that of the lower, so that as the clay on the conveyor belt passes between the first poles of the magnets, the magnetic particles are attracted towards the upper poles, and jump toward it. They are intercepted, however, and prevented from reaching the upper pole by the cross-belt which removes them quickly from the field and influence of the magnets and allows them to drop into a receptacle provided at one side.

High Intensity Magnetic Separation (Type B).—The separation of iron bearing minerals from clays is accomplished with the B high intensity separator with a gradual step by step process. The material moves from pole to pole of progressively increasing intensity which is made possible by independent adjustments of each magnetic gap and by accurate control of the current flow to the coils. As the material is conveyed to the take-off rings, it passes through a strong magnetic field which overcomes a considerable amount of reluctance before reaching the intense magnetic gap where the separation takes place. The first gap of the magnet, which is usually greater than the second, removes the stronger magnetic particles. This also partly overcomes the reluctance of the feebly magnetic materials and makes them more susceptible to the influence of the closer adjusted gap of the second pass, resulting in a better separation.

Experimental Methods.—Ten kilogram samples of two raw ground sewer pipe mixtures, screened through a 10-mesh sieve were treated with a low intensity magnetic separator and the two high intensity magnetic separators, types A and B.

The portions removed by the magnet as well as the non-magnetic portions were molded into cones and fired at a temperature corresponding approximately to that at which sewer pipe are fired. The appearances of the magnetic portions after firing were then noted.

Similar experiments were conducted on the same clays after roasting at a dull red heat for comparison, since it is claimed that the magnetic susceptibility is increased by roasting.

Experimental Results.—The results given below represent the percentages removed magnetically by machines of greater and greater strength as the ground clay was passed through them successively. The non-

magnetic portion is that unaffected by the magnetic treatment and, therefore, represents the purified clay.

TABLE I

Treatment of raw clay 1.23 with type A high intensity magnetic separator with 220 volts and the belt moving at a speed of 60 feet per minute.

Magnetic intensity	Weight, grams	Portions separated, per cent	Amperes	Gap, inches
Medium high	250	2.5	1	3/8
Extreme	310	3.0	2 1/2	3/8
Non-magnetic	9600	94.5	2 1/2	3/8
Total	10160	100.0		

TABLE II

Clay 1.23, roasted at a dull red heat for 3 minutes, and treated with a type A high intensity magnetic separator, with 220 volts and with the belt moving at a speed of 60 feet per minute.

Magnetic intensity	Weight, grams	Portions separated, per cent	Amperes	Gap, inches
Medium	1920	27.8	...	3/16
Medium high	2040	29.6	1	3/8
Extreme	1320	19.1	2 1/2	3/8
Non-magnetic	1620	23.5	2 1/2	3/8
Total	6900	100.0		

The portions separated as well as the purified clay are shown after firing in Fig. 2. The cone marked 1 represents the portion removed from

FIG. 2.—Portions separated with a magnet and purified clay after firing.

the raw clay 1.23, with a medium high intensity. Cone 2 represents the portion removed with an extreme magnetic intensity and cone 3 the purified clay (see Table I). Cones 1 and 2 fused to a black slag due to a high con-

tent of iron compounds, which they contain, while the purified portion, cone 3, is practically free from coarse iron blister, with the exception of a few small black spots.

The cone marked 4, see Fig. 2, represents the portion separated from the roasted clay 1.23 with a medium magnetic intensity, see Table II. Cone 5 represents the portion removed with a medium high intensity magnet. Cone marked 6 represents the portion removed with an extreme magnetic intensity and cone 7 represents the portion which was non-magnetic. Although cones 4, 5, and 6 are darker than cone 7, due to their higher content of iron compounds, the cones retained their shape and did not fuse to a slag as cones 1 and 2 did, indicating that the portions separated from the raw clay contained a larger per cent of iron compounds than that separated from the roasted clay.

Cones marked 7, 8, and 9 represent Seger cones 1, 4, and 8, respectively. These samples were fired to cone 8. It is apparent that portions 1 and 2, separated from the raw clay, would cause roughness on pipe if fired to this temperature and that removing this magnetic portion from the clay would produce a pipe of better finish.

The results obtained on clay 1.09 are given in Tables III and IV below.

TABLE III

Treatment of raw clay 1.09 with a type A high intensity magnetic separator with 220 volts and with the belt moving at a speed of 60 feet per minute

Magnetic intensity	Weight, grams	Portions separated, per cent	Amperes	Gap, inches
Medium high	40	0.4	1	3/8
Extreme	80	0.9	2 1/2	3/8
Non-magnetic	9120	98.7	2 1/2	3/8
Total	9240	100.0		

TABLE IV

Clay 1.09, roasted at a dull red heat, and treated with a type A high intensity magnetic separator with 220 volts and with the belt moving at a speed of 60 feet per minute

Magnetic intensity	Weight, grams	Portions separated, per cent	Amperes	Gap, inches
Medium high	80	1.1	1	3/8
Extreme	100	1.3	2 1/2	3/8
Non-magnetic	7200	97.3	2 1/2	3/8
Total	7380	99.7		

The portions separated as well as the purified clay are shown after firing in Fig. 3. The cone marked 1 represents the portion separated from the raw clay 1.09 with a medium high intensity (see Table III). Cone marked 2 represents the portion removed with an extreme magnetic intensity and cone 3 represents the purified clay. Cones 1 and 2 fused to a black slag due to the high content of iron compounds which they con-

tain, while the purified clay, marked 3, is practically free from coarse iron specks with the exception of a few small black spots.

The cone marked 4 represents the portion separated from the roasted sample of clay with a medium high intensity (see Table IV). The cone 5 represents portion B removed with an extreme magnetic intensity and cone 6 represents the portion which was non-magnetic. Cone marked 4 fused to a black slag due to the high content of iron compounds which it contains. Cone 5 contains a considerable amount of iron compounds as is shown by its black color but the content of iron in this instance was not sufficient to cause it to deform as was the case with cone 4. The purified

FIG. 3.—Portions separated with a magnet and purified clay after firing.

cone 6 contained practically no coarse iron specks. In this case again it appears that the portion separated from the raw clay contains a greater percentage of iron oxide than that removed from the roasted clay.

The cones marked 7, 8, and 9 represent Seger cones 1, 4, and 8, respectively. These samples were fired to cone 4. In this case it is again apparent that the magnetic portions 1 and 2 would cause roughness if they were present in a sewer pipe body fired to this temperature and that pipe of better finish may be produced by the electromagnetic separation of the iron bearing minerals from the clay previous to molding.

The results obtained with the high intensity magnetic separator type B on the same clays as were tested above are given in Tables V and VI below.

TABLE V

Treatment of raw clay 1.23 with a type B high intensity magnetic separator.

Magnetic intensity	Weight, grams	Portions separated, per cent
Extreme	22.0	2.23
Non-magnetic	956.0	97.75
Total	978.0	99.98

TABLE VI

Treatment of raw clay 1.09 with a type B high intensity magnetic separator.

Magnetic intensity	Weight, gram	Portions separated, per cent
Extreme	4.0	0.55
Non-magnetic	724.0	99.45
Total	728.0	100.00

The portions removed with this separation fused to a black slag when fired to cone 3 appearing similar to those portions removed with the type A separator.

The separator A, however, removed a higher percentage of iron bearing minerals from the clays than the separator B. The results obtained with the high intensity magnetic separator B are about the same as were obtained with the medium high intensity separator A.

Summary and Conclusions

Tests were made on ground clays to determine if the coarse iron bearing minerals which cause roughness on sewer pipe may be separated with a high intensity magnetic separator. The laboratory tests indicate that it is possible to remove considerable of the coarse iron bearing minerals by such a separation. The expense of this treatment is not prohibitive to plants sustaining large losses due to this defect, and in some cases it may not only improve the ware but also reduce the cost of manufacture.

CAPPING FOR COMPRESSION SPECIMENS[1]

By Harry D. Foster

ABSTRACT

Compressive strength tests have been made on tile capped with unretarded gypsum with neat Portland cement, with a mixture of three parts by volume of Portland cement to one part of unretarded gypsum and on tile whose bearings were ground. The tile whose bearings were ground gave the highest strengths. The interpretation of the results was based on the workability and yielding of the cap and on the influence of the bearing block. As it is impossible to grind the bearings of all types of tile, a cap of three parts of Portland cement to one part of unretarded gypsum is advocated as giving the highest and most consistent results.

A survey of the methods of testing hollow tile in compression shows that many testing laboratories use for caps a plastic mortar of calcined gypsum (plaster of Paris), while others use a mixture of calcined gypsum and Portland cement, or in some cases neat Portland cement whose set has been accelerated. This condition may be in part responsible for the variations in strength and for the many discrepancies which are constantly arising in connection with testing of tile. In order to obtain some data which would help to clear up the situation and on which a more definite method of making compression tests can be based, the present series of tests was undertaken. The results show that the strengths obtained depended to some extent on the cap. With very soft caps which flowed freely lower strengths were obtained than with fairly hard caps of material that had a proper degree of workability.

The tile used were all of the 6-cell end construction type from a plant using typical Ohio fire clay and were tested with load applied parallel with the cells. The gypsum was unretarded and had a time of set of 18 minutes and a normal consistency of 50%. The Portland cement had a time of initial set of 5 hours and 15 minutes and a final set of 8 hours and 10 minutes, with a normal consistency of 22%.

In order to determine the age at which tile capped with each of the materials or with a combination of them, should be tested, 2-inch cubes were made and tested in compression at ages ranging from 20 minutes to 7 days. As shown in Figure 1, the neat gypsum attains a large proportion of its maximum strength within a few hours, a very rapid gain obtaining within the first hour. The cement and gypsum mixtures were very weak at early ages but the increase in strength was fairly uniform after the first 8 hours, reaching the full strength of gypsum in about 3 days. The neat Portland cement did not develop appreciable strength in less than one day. Its increase thereafter was very rapid, at 7 days being 4807 lb. per sq. in. After making a study of this plot it was decided to make compression tests

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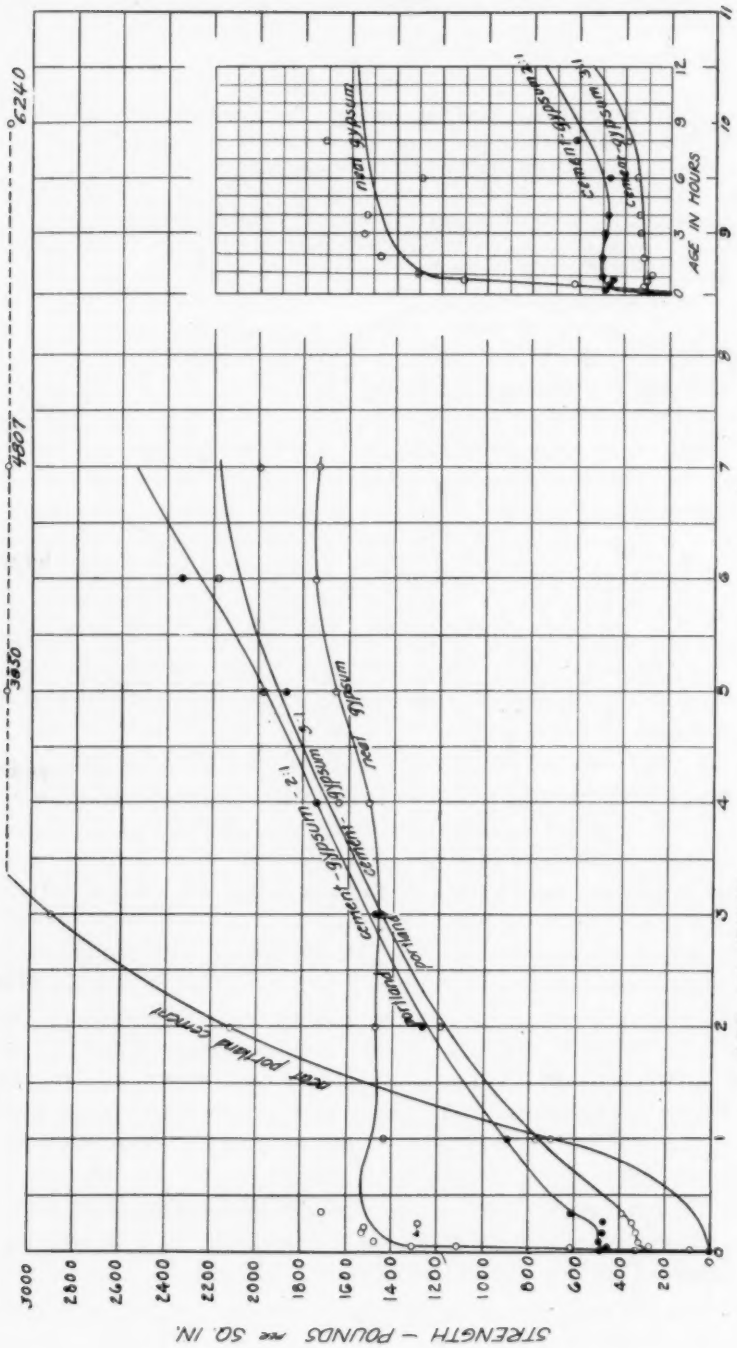

FIG. 1.—Compressive strength of two-inch cubes of the various capping materials used.

of tile when capped with neat gypsum at the ages of 1 hour and 3 hours; of tile capped with a mixture of three parts by volume of Portland cement and one part of gypsum at ages of 1 hour, 3 hours, 3 days and 7 days; and of tile capped with neat Portland cement at the age of 10 days. From the standpoint of workability any of these materials, except, possibly, neat Portland cement, could be used in capping tile. The neat gypsum and the mixtures of cement and gypsum gave early initial sets so that a capped tile could be removed from the capping block within 15 minutes after the cap was made. The cement, however, did not set sufficiently to allow the tile to be moved for 6 to 8 hours.

After coating the bearing surfaces and adjacent parts with shellac to keep the tile from absorbing water from the plastic cap, they were capped in the following manner: A quantity of the capping material mixed with enough water to give it a consistency slightly exceeding the normal was spread on a glass plate which had been moderately coated with oil. One bearing surface of the tile was then set in this plastic material and while holding the axis of the tile as nearly vertical as possible, a single and firm pressure was applied. As soon as this cap had hardened sufficiently so that the tile could be moved, the other bearing surface was capped. The caps were $^1/_{16}$ to $^1/_8$ inch thick. No caps were patched, imperfect ones being replaced with new ones.

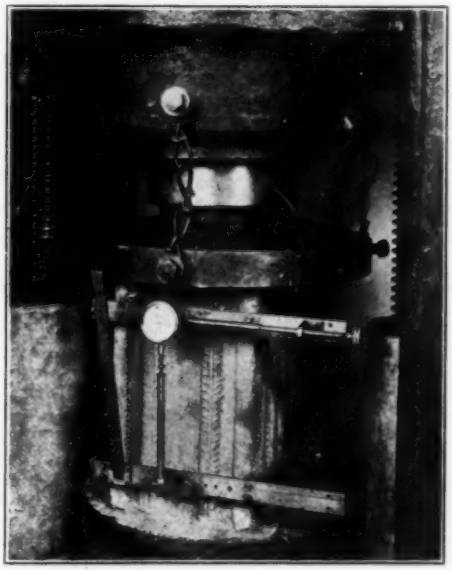

Fig. 2.—Bearing block and compressometer used in compression tests

The tests were made in a 300,000 pound Riehlé testing machine, the speed of the moving head being slightly less than 0.05 inches per minute. The load was applied continuously, readings of the compressometer and measurements of the distance traveled by the moving head being taken at loading increments of 500 pounds per square inch of net sectional area of the tile. By taking the distance traveled by the moving head with reference to the fixed head with an Ames gage, the total deformation of the tile and cap was obtained. Then as the deformation of the tile was measured with the compressometer, the deformation or flow of the cap was readily calculated.

The bearing block and compressometer used are shown in Figure 2. The center of the spherical bearing surface is located approximately in the lower plane surface of the block. By carefully centering the tile and rotating the top member of the bearing block as the moving head of the machine was lowered no difficulty was encountered in obtaining consistently good failures typical with that of Figure 3.

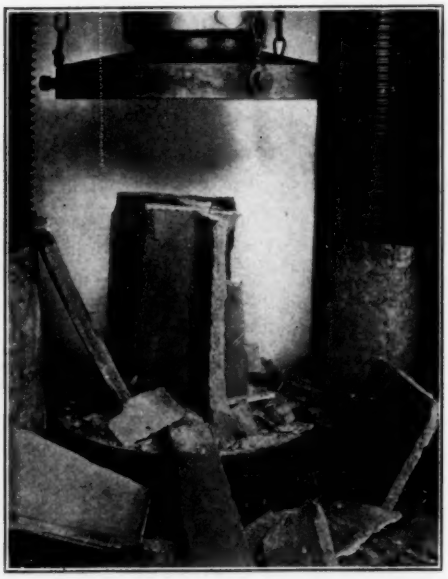

FIG. 3.—Tile after compression tests showing a typical failure.

Representative pieces of tile were selected after each compression test for absorption determinations and the results from strength tests of the tiles which were appreciably above or below the absorption average were discarded. This left tile having nearly uniform absorption from which all the results summarized in Table I were taken.

From the curve given in Figure 4 it is seen that in all cases the deformation of the cap was appreciable and with some materials larger than that of the tile. It is noted that the mixture of Portland cement and gypsum at early ages deforms very rapidly from the beginning of the test and is apparently unsuitable for use as capping material at these ages. At three days and seven days, however, this cap did not deform greatly. The deformation of the neat gypsum cap was not excessive up to loads of 1000 to 1500 lbs. per sq. in., when it weakened and began to show a decided flowing. The deformation and flow of the neat Portland cement cap was very gradual,

TABLE I

Capping material	Age when tested	No. of tests	Average max. load in lbs. per sq. in. of net sectional area	Average percentage absorption	Relative strength
Neat gypsum	1 hour	8	5824	9.24	0.884
	3 hours	6	5913	8.94	0.897
3 parts of Portland cement to 1 part of calcined gypsum	1 hour	7	5778	9.03	0.876
	3 hours	6	5756	9.55	0.873
	3 days	7	6176	9.18	0.936
	7 days	9	6593	9.14	1.000
Neat Portland cement	10 days	6	6107	9.09	0.926

the deformation curve, after initial adjustments had taken place, being nearly a straight line up to the point where the instrument was taken off.

From Table I it is seen that a cap of three parts of Portland cement and one part of gypsum at the age of seven days gives the highest strength for hollow tile; that neat gypsum or the cement-gypsum mixture at 1 and 3 hours gives results averaging about 89 per cent of those obtained with the mixture at 7 days; and that the mixture at 3 days gives results almost equivalent to those obtained with neat Portland cement at 10 days.

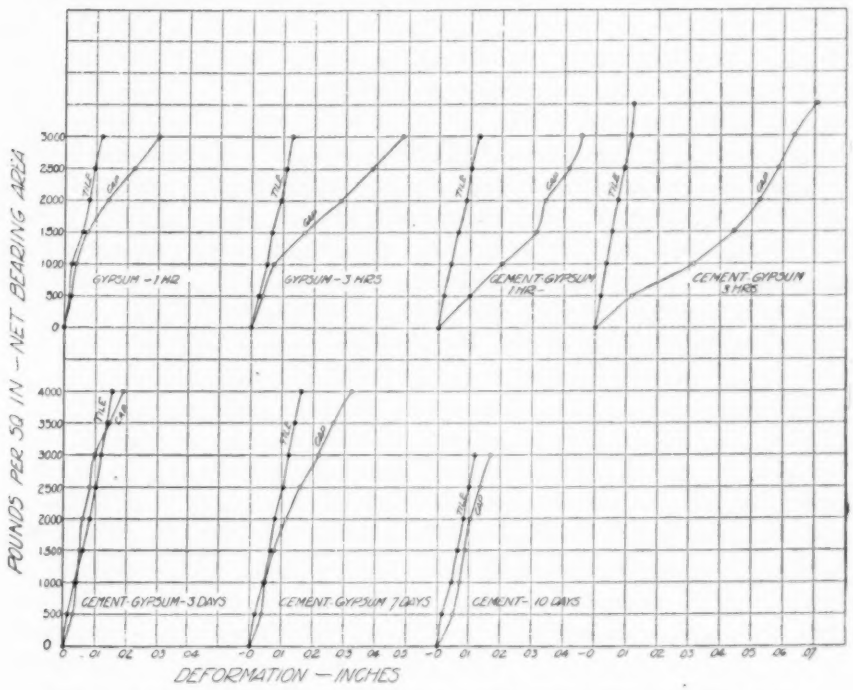

FIG. 4.—Average deformation of tile and caps from compression tests of tile.

The strengths developed with the various caps can be explained from the relative strengths and other properties of the capping materials and the deformation curves. With the softer caps and with the neat Portland cement cap, popping sounds due to adjustments at high spots were heard at earlier periods of the test than when caps of the mixture at 7 days were used. In the case of the Portland cement caps this behavior and the lower tile strengths attained than with the weaker 3:1 capping mixture, can be attributed to the more yielding consistency of the neat cement on the capping plate, the weight of the tile cutting through the capping material leaving only a very thin layer under the high points. The cement and

gypsum mixture attained a set in a minute or two sufficient to support the tile at all points.

Since making the above tests, another series of tests of 8 by 12 by 12 end construction tile has been made, about half of the number being capped with the 3:1 cement-gypsum mixture and the remainder having bearing surfaces ground smooth by means of a Dory type of grinder. The nine capped tile with an average absorption of 8.3% gave a strength of 6694 pounds per square inch of net sectional area, and ten tile with ground bearings having an average absorption of 8.7%, gave an average strength of 7426 pounds per square inch. This is an increase of 10.8 per cent obtained by grinding the bearings, which does not fully represent the gain in strength due to the slight difference in hardness of the two lots, as indicated by the absorption. In the tests with ground ends no popping sounds were heard until near the maximum load. It is difficult to state whether this increase was due wholly to more uniform bearing or due in part to greater lateral restraint at the bearing surfaces, some flow with consequent allowance for lateral expansion of the vertically compressed tile being incident with all capping materials used, particularly at loads near failure. That the effect of restraint at the bearing surfaces in increasing the strength of tile is probably not large may be concluded from results of tests of similar tile in 6-inch and 12-inch lengths. In tests covering a wide range in clay, 24 half tile having an average absorption of 13.91% gave an average compressive strength of 3988 pounds per square inch of net area, as against 3867 pounds per square inch for a similar lot of whole tile having an average absorption of 10.87%. It is apparent that for tile 8 to 12 inches in lateral dimensions, neither length allows for the full free action of the resultant shearing forces that are concerned in compression failure, which conditions, combined with possible restraint at the bearings, make the so-called true strength unattainable in compression tests of units of the sizes manufactured. That such strength may be no higher than that obtained with available methods of testing follows from the above consideration, even after making allowance for incidental eccentricities of loading. In the tests a well proportioned spherical steel block was used, that was carefully centered. In the tests of tile with ground bearings the average range between high and low values for tile of the same percentage absorption was about 13 per cent, only part of which should be attributed to eccentricity of loading, the other being due to variations in the tile. Results of tests with capped tile indicate variations of no larger amount and justify the belief that errors attributable to uneven bearings, bending and eccentric application of load can be kept down to limits where they are not of serious consequence.

The hydraulic bearing, while making possible adjustment of inclination of bearing surfaces during test, cannot be made practically adjustable

for irregularities of the bearing surfaces of the specimens sufficient to avoid capping or grinding the bearing ends. In attempts so far made in this direction a yielding material such as rubber has been used on the contact surfaces, which, with its high ratio of lateral expansion to longitudinal compression, induced lateral tension stresses and consequent splitting of the specimen on longitudinal planes, an effect much more disturbing and foreign than the lateral restraint incident with solid bearing contacts. An ideal bearing material should expand the same laterally on its bearings with the specimen for a given unit load as the specimen itself, and at the same time be yielding enough to adjust itself to the irregularities of the bearing, two conditions that one material cannot generally fulfill. The methods that can be recommended as standard procedure therefore comprise the use of metal bearings, and capped ends for the specimens, not many laboratories having the necessary grinding equipment, also, tile tested with cells horizontal cannot generally have their bearing surfaces trued by grinding without material weakening. The tests show that consistent and high results can be attained with caps of a mixture of 3 parts Portland cement and 1 part gypsum, aged 7 days.

The time necessary for aging a cap is generally available for acceptance tests since they are usually made before the shipment leaves the factory, samples being selected and sent to a testing laboratory. In cases where immediate tests are required, a cap made of unretarded gypsum of the required strength and aged not less than one hour should be used, as giving the highest strengths at the given age, although lower than those that would be obtained with the cement-gypsum mixture aged for a longer period.

The results obtained in this investigation apply generally to end construction tile with some possibility of changes in relative values for tile differing markedly in strength from those tested. For other material and shapes of test specimen, the results will not apply quantitatively although the variations will probably be in the same general direction.

The work which supplied the results herein given is a part of a general investigation of the fire resistance and related properties of hollow tile conducted at the Bureau of Standards in coöperation with the Hollow Building Tile Association. Acknowledgment is due to S. H. Ingberg, in charge of the Bureau's fire resistance work, for aid in planning the investigation and interpreting the results.

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SOME NOTES ON THE MEASUREMENT OF TRANSLUCENCY OF CERAMIC BODIES[1]

By Cullen W. Parmelee and Roy E. Lowrance

The measurement of the translucency of pottery bodies has generally been done by methods which have been unsuited for obtaining exact data. Examples of these are the methods described by Ashley, Ogden and others[2] in the *Transactions of the American Ceramic Society*. Briefly these depend upon the determination of the maximum thickness of a test piece which permits the shadow of a wire or wire mesh to be visible to the naked eye, if the wire or wire mesh is interposed between the test piece and the source of light. The relative translucencies of the test pieces are thus based upon the order of maximum thickness of the same. In other words it is not much more satisfactory than the age-old method of observing the shadow of one's finger when it is placed back of a dish held in a strong light.

Priest[3] has suggested a more exact method in which a photometer was used. Insofar as we know, the process has not been used. In *The Pottery Industry*,[4] the results obtained by the use of a photometer in which a standard lamp was employed are given. Details of the method are not recorded.

The most complete investigation yet reported is that recently published by Steger.[5] He used a photometer of the Bouguer type. His results are relative since they are always referred to certain test pieces which he adopted as standards.

During the past year some experimental work[1] has been carried on in the laboratory of the Department of Ceramic Engineering, University of Illinois, in which a photo-electric cell has been employed. The results which were obtained are regarded as important as indicating the practicability of this apparatus, yet we are not prepared to publish the results of the study of the bodies, because we are desirous of rechecking them, which work is now in progress.

The principle involved in the use of the photo-electric cell is that ultra-violet light, if allowed to fall upon a metal surface causes it to become elec-

[1] The following paper is based upon the results obtained by the junior author in the use of this method in the preparation of a thesis to meet the requirements for the degree of B.Sc. in Ceramics, at the University of Illinois.

[2] Lester Ogden, "Effect of Composition on the Strength of Porcelains," *Trans. Amer. Ceram. Soc.*, **13**, 400 (1911); Charles Weelans and H. E. Ashley, "Rept. of the Comm. on Classification of Whiteware," *ibid.*, **13**, 102 (1911); C. W. Parmelee and G. H. Baldwin, "Talc as a Body Material," *ibid.*, **15**, 532 (1913); A. S. Watts, "The Use of Mixed Potash-Soda Feldspars in Porcelains," *ibid.*, **16**, 212 (1914); C. C. Lin, "A Study of High Fire Porcelain," *Jour. Amer. Ceram. Soc.*, **2** [8], 622 (1919).

[3] Irwin G. Priest, "The Bureau of Standards Contrast Method for Measuring Transparency," *Trans. Amer. Ceram. Soc.*, **17**, 150 (1915).

[4] *The Pottery Industry*. Dept. of Commerce, Misc. Series **21**.

[5] Steger, *Ber. D. Keram. Gesell.*, **2** [1], 9 (1921).

trically charged, and ions are set free which move toward the other electrode. The direction of the movement of the current will depend upon the nature of the charge. It has been found that the alkali metals are very sensitive to the influence of wave lengths of light within the visible spectrum. The apparatus which has been devised for use for the study of this phenomenon consists of a glass tube, the interior of which is coated with a layer of a metal. The tube is then evacuated and recharged with a small amount of argon gas and then sealed. If potassium is the metal used in such a cell it will be as sensitive to blue light as the human eye in its most sensitive condition. The blue light will impart 3×10^{-7} erg per second per sq. cm. of potassium surface exposed[1] producing a measurable photo-electric current of 5×10^{-15} amp. It has been found that if disturbing effects are absent, the relation between the total photo-electric current and the intensity is a linear one, and a strict proportionality exists between the intensity of illumination and the number of electrons emitted. This proportionality holds for light feeble as 3×10^{-9} erg per sq. cm. per sec. for blue light, and 2×10^{-7} erg per sq. cm. per sec. of orange light. The former value[2] is below the "threshold" value for the human eye. This holds over a wide range of illumination, from that which is too feeble to be visible to the eye to an illumination which is comparable to the light of the sun. Owing to the fact that a photo-electric cell is so sensitive to the influence of light, it has found use in many ways; for example, in radiometry, light intensities of smaller order of magnitude may be studied than is possible with a thermopile. The photo-electric cell is also used for the study of luminescence, for measuring the rapidity of photographic shutters, the decay of phosphorescence, and it has been used very successfully in the study of the light phenomena associated with solar and lunar eclipses.

The rate at which these electrons are emitted from a metal surface is influenced by certain conditions which need not be discussed. It is sufficient to say that these conditions can be maintained under sufficiently close control so that the apparatus is entirely practical for use by persons of limited laboratory experience.

The operation of the photo-electric cell is based upon quite a different principle than the selenium cell suggested by Bleininger.[3] The photo-electric cell generates a current of electricity, while the selenium cell changes its resistance when exposed to rays of light.

The particular cell which was employed in these experiments was kindly supplied by Dr. Jacob Kunz of the Department of Physics, University of Illinois. The design of the cell is shown in the accompanying sketch. The interior of the cell was coated with a thin film of silver over the en-

[1] Hughes, "Photo-electricity," p. 60.

[2] *National Research Council Bull.*, "Report on Photo-electricity," by Hughes, p. 106.

[3] A. V. Bleininger, *Trans. Amer. Ceram. Soc.*, **15**, 543 (1913).

tire surface, with the exception of a small round opening which was left for the admittance of light. Upon this film of silver was deposited a thin film of potassium. This double coating of silver and potassium formed the cathode or negative terminal of the cell. The anode consisted of a hoop of platinum wire, directly in front of and a few centimeters from the cathode. The cell had been completely evacuated, and then a small amount of argon was introduced before it was sealed. This rendered the cell much more sensitive to the effect of light. The set-up of the apparatus is shown in the accompanying diagram. A resistance of 100,000 ohms was connected in series with the cell in order to protect it from a sudden increase in voltage. A galvanometer of the D'Arsenval type was used which had a sensitiveness of 2.711 megs. and a figure of merit of about 10^{-10}. Dry batteries connected in series furnished one hundred and twenty-five volts.

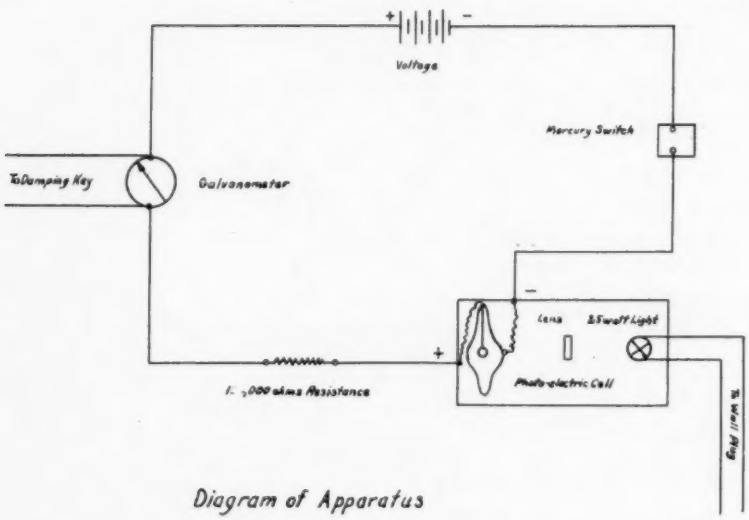


Diagram of Apparatus

The cathode was connected through a mercury switch to the negative end of the source of the voltage. The positive end of the cell was connected directly to the galvanometer.

The photo-electric cell was placed in a small, light-tight metal box, one side of which had an opening situated opposite to the window of the cell. To this opening on the box was attached a metal frame to which could be secured the small test pieces. A sliding shutter was provided at the opening so that it could be opened or closed at will. The cell was placed in a large wooden box which was painted black on the inside. A 25-watt lamp and a lens were placed opposite the cell so that parallel rays of light would fall upon the test pieces, situated at the opening opposite the window of

the cell. With this apparatus, the work then consisted of the measurement of the amount of current generated by the photo-electric cell when a test piece had been interposed between the source of light and the cell.

The test pieces which were studied consisted of a number of compositions which had been selected with reference to the ordinary range of pottery bodies. In order to insure as nearly uniform thickness as possible, they were first burned to a temperature of 1000° and then ground to the desired thickness. After which, they were refired to the maximum temperature which, in this case, was cone 10. Ten current readings were taken of each piece, and the variations were found to be not greater than $1^1/_2$ mm. on the galvanometer scale. After the readings the thickness of the test pieces was determined by means of vernier calipers. Measurements were taken from each of the 4 corners and the mean taken as the true thickness of the piece. The test pieces measured 5 cm. x 5 cm., and the thickness of the test pieces varied from 1.2 mm. to 3.0 mm.

Results obtained seem to indicate that the translucency is inversely proportional to the thickness of the specimen. This is in accordance with the experience of others, namely, Ashley and Williams,[1] and also Steger.[2]

The translucency increases with an increase of the ratio of the feldspar to the clay-silica content. This is especially true in bodies of low silica content. The increase is very rapid in mixtures of low silica (15%) but slight with 35% silica. Only a slight increase is obtained with a clay content above fifty per cent at this cone temperature.

With a constant feldspar content, the translucency increases with an increase in silica, the increase being rapid above 25% feldspar. It was found that the results conformed in general with those which have been reported by Dr. Hecht.[3]

At present we are engaged in checking the results which have been obtained by this method, and also in extending our field of study of translucency as influenced by body composition and other conditions, namely, color.

The advantage of having such a simple apparatus available for determining translucency in the terms of absolute units is obvious.

It seems worth while also to investigate this method as possibly having a useful application in the study of the color of the transmitted light.

[1] Charles Weelans and H. E. Ashley, *loc. cit.*

[2] Steger, *Ber. Deut. Keram. Gesell.*, **2** [3], 65 (1921).

[3] H. E. Ashley, "Notes on Dr. H. Heckt's Investigation," etc., *Trans. Amer. Ceram. Soc.*, **13**, 258 (1911).

THE EFFECT OF SOME SUBSTITUTES FOR TIN OXIDE ON THE OPACITY OF WHITE ENAMELS FOR SHEET STEEL[1]

By R. R. Danielson and M. K. Frehafer

ABSTRACT

The effect of replacements of tin oxide on opacity of enamels is always of interest. This investigation includes a study of some of the commercial substitutes for tin oxide in a standard frit as well as others which are not in common use. Zirconium oxide and sodium antimonate are apparently the best substitutes and rank very close to tin oxide. Next in order is zirconium silicate, although the purity of the material is of course very important. Opacity does not always increase with increase in amount of opacifier used. Proper calcination of opacifiers is of importance in their effect on opacity.

Visual estimation is not an accurate method for determining the opacity of enamels, although it may be suitable for classifying enamels for such purposes as stove work and table tops. For accurate determination of reflecting value, the method employed by the Colorimetry Section of the Bureau of Standards is described. This involves the use of the spectrophotometer apparatus with illumination box as developed at the Bureau and the calculation of the total diffuse reflection from the spectrophotometric data.

PART I

Opacifying Effect of Tin Oxide and Its Substitutes

Introduction

The subject of the replacement of tin oxide in enamels is always of interest to enamelers. This is due, in part, to the desire to produce enamels of the highest opacity at the lowest cost and in part to the demand for materials which may add some desirable property to the enamel and still not decrease the opacity of the enamels. (The term *opacity* as used by enamelers signifies the power of the enamel to mask the ground coat to which it is applied. As the thickness of the enamel layer is increased, the smaller is the amount of light that reaches the ground coat, and that reaches the observers' eye from the ground coat. A thin layer of enamel of high opacity will be equivalent in this respect to a thick layer of low opacity; but the advantage of using the former is obvious.)

This investigation is concerned only with the comparative effect of tin oxide and some of its substitutes on the opacity of the enamel, and methods for accurately determining opacity, by means of the diffuse reflecting power. Since tin oxide is almost invariably added to sheet steel enamels in the mill during grinding of the frit, this work will deal with the replacement of tin oxide in the mill batch.

Preparation of Enamels

A standard white frit of the following composition was used in this investigation:

[1] By permission of the Director, U. S. Bureau of Standards.

Batch Weight	
Borax	25
Feldspar	32
Quartz	18
Soda ash	4
Sodium nitrate	3
Cryolite	12
Antimony oxide	2
Fluorspar	4
	100

The frit was ground in approximately 2.0 lb. batches in a ball mill, with a constant mill addition of 6% of clay, 0.5% of magnesium carbonate and 60% of water. The addition of opacifiers was varied in amounts, in the case of tin oxide being 7%, while the addition of substitutes varied from 7% to 11%.

In Table I is given a list of the enamels designated by their laboratory number and the type and percentage of opacifier added to the frit in the milling.

Table I

Type and Percentage of Opacifier Used in the Enamel

Laboratory number	Opacifier	Per cent used	Source	Remarks
1	Tin oxide	7	Trade	....
5	Sodium antimonate	7	Trade	....
6	Sodium antimonate	9	Trade	....
7	Sodium antimonate	11	Trade	....
11	Titanium oxide	7	Trade	Impure material
9	Magnesium aluminate	7	Bureau	Calcined at approx. 1200°C
2	Zinc oxide	7	Trade	....
3	Zinc oxide	11	Trade	....
8	Zinc aluminate	7	Bureau	$ZnO.Al_2O_3$ calcined at approx. 1200°C
16A	Zinc aluminate	9	Bureau	$ZnO.Al_2O_3$ calcined at 1000°C—2 hours
16B	Zinc aluminate	9	Bureau	$ZnO.Al_2O_3$ not calcined
16D	Zinc aluminate	9	Bureau	$2ZnO.3Al_2O_3$ not calcined
13	Commercial substitute	7	Trade	....
15A[1]	Feldspar opacifier	9	Bureau	Calcined at 1000°C
4	Zirconium oxide	7	Trade	....
14	Zirconium oxide	9	Trade	....
10	Zirconium product	7	Trade	Claimed to be zirconium oxide
17	Zirconium product	9	Trade	Claimed to be zirconium oxide
18	Zirconium product	11	Trade	Claimed to be zirconium oxide
12	Zirconium silicate A	7	Trade	From dealer A
19	Zirconium silicate A	9	Trade	
20	Zirconium silicate A	11	Trade	
25	Zirconium silicate B	7	Trade	Calcined 1000°C
25A	Zirconium silicate B	7	Trade	
26	Zirconium silicate B	9	Trade	From dealer B
27	Zirconium silicate B	11	Trade	

[1] Feldspar opacifier: feldspar 51.0, soda ash 12.0, whiting 13.0, fluorspar 7.0, cryolite 9.0, sodium antimonate 8.0; ground in ball mill.

Preparation of Enameled Test Plates

The various enamels were applied by means of an air spray to iron plates which had previously been coated with a ground coat of the following composition:

Frit		Mill	
Borax	28.5	Frit	100
Feldspar	31.2	Clay	6
Flint	20.0	Borax	2
Soda ash	9.0	Water	50
Sodium nitrate	4.0		
Fluorspar	6.0		
Cobalt oxide	0.35		
Manganese oxide	0 95		
	100.00		

The size of the test plates was 53 x 35 mm. (approximately $1^3/_8$ in. x 2 in.) made to conform to the dimensions of the spectrophotometric apparatus. The same plates were also used for classifying the enamels by visual observation.

In order to prevent variations due to thickness of the enamel coating, a number of trials was made for each enamel, and plates having approximately the same weight of enamel were used for the determination of opacity. All enamels were applied in two applications. The weights of enamel on the test plates after firing are included in Table II.

Classification of Opacifiers by Visual Estimate

In order to classify the opacifiers, two methods were used. In the first, the plates which had been coated with the various enamels were carefully examined and placed in the order of opacity by two observers. While there were some minor differences of opinion as to proper classification, column 5 of Table II represents the final classification agreed upon by two observers. In Class A are grouped those compositions giving excellent opacity, such as might be required for reflector enamels. Class B contains those compositions which might be suitable for products in which high opacity or reflecting value is not essential. Class C gives those compositions which might serve as partial substitutes for tin oxide, and Class D, those which are unsatisfactory for white enamels.

Classification of Opacifiers by Reflecting Power

Since it was impossible to differentiate in some cases between enamels having increasing amounts of opacifying agents, it seemed desirable to resort to some more definite method of comparison than is possible in

visual observation. The more satisfactory enamels were, therefore, tested by the Colorimetry Section of the Bureau for spectral reflection values and total reflection. Only the results of these determinations are given in Part I; but a brief description of the scientific method and the spectrophotometric apparatus used for these determinations and also the spectral reflection curves obtained, are given in Part II of this report. This method yields results that are more accurate than has been considered necessary for this type of work, but the need of greater accuracy than is possible from visual observation becomes apparent from the results of this investigation.

Result of Classifications

The following Table II gives, in column 1 the laboratory number of the sample, in column 2 the kind of opacifier used and in column 3 the amount in per cent; in column 4 is the weight of the enamel in grams; in column

TABLE II

CLASSIFICATION OF ENAMELS FOR OPACITY

Lab. no.	Opacifier	Per cent used	Weight in grams of enamel on test plate	Classification as estimated by two observers	Per cent total light reflected
1	Tin oxide	7	1.43	A	69.4
7	Sodium antimonate	11	1.48	A	67.2
4	Zirconium oxide	7	1.39	A	65.8
14	Zirconium oxide	9	1.42	A	65.4
6	Sodium antimonate	9	1.41	B	64.8
5	Sodium antimonate	7	1.44	B	63.0
27	Zirconium silicate—B	11	1.48	B	64.8
25A	Zirconium silicate—B (calcined)	7	1.39	B	60.6
26	Zirconium silicate—B	9	1.48	B	63.0
25	Zirconium silicate—B	7	1.41	B	58.2
13	Commercial substitute	7	1.41	C	55.5
15A	Feldspar opacifier	9	1.34	C	58.2
16B	Zinc aluminate	9	1.35	C	54.5
16A	Zinc aluminate (calcined)	9	1.53	C	55.8
18	Zirconium product	11	..	C	..
8	Zinc aluminate (calcined)	7	1.56	D	56.6
12	Zirconium silicate—A	7	1.38	D	52.2
16D	Zinc aluminate	9	1.31	D	48.5
20	Zirconium silicate—A	11	1.33	D	48.3
2	Zinc oxide	7	..	D	..
3	Zinc oxide	11	..	D	..
9	Magnesium aluminate	7	..	D	..
10	Zirconium product	7	1.38	D	51.0
11	Titanium oxide (impure)	7	..	D	..
17	Zirconium product	9	1.36	D	..

5 there is given the classification of the enamels according to the eye estimate of two observers, and in column 6 is the fraction of sunlight diffusely reflected, the calculation of which is explained in Part II.

Not all of the samples were examined for reflection; hence the table is not complete. A sufficient amount of data has been obtained, however, to bring out some very important facts.

From the above table, it is to be noticed that there are some disagreements between the *estimated* classification in order of opacity and the classification according to the total reflection. Samples 25 and 15A for instance, which according to column 6 belong in the same class, have been assigned to different classes, and the classification of sample No. 8 is not consistent. In Classes B, C, and D, the order of arrangement by visual estimate is not the same as the order of arrangement by total reflection. Two causes contribute to these discrepancies: the presence of hue (blue or yellow) and the presence of glare. The former has the tendency, for the enamels appearing slightly blue, to lower the observer's estimate; the presence of glare or shine on the surface of the enamel tends to raise the estimate.

While the presence of hue is, of course, somewhat of a disadvantage in an enamel intended to be white or without hue, the shine or glare is a decided advantage sometimes, depending on the use to which the enamel is to be put. This is particularly true of enamels for stove parts, table tops and similar ware.

The effect of the treatment of the enamel and of the amount of opacifier used can readily be ascertained by reference to Table III.

TABLE III

Lab. no.	Opacifier	Per cent used	Weight in grams of enamel	Total light reflected	Treatment
1	Tin oxide	7	1.43	69.4	....
7	Sodium antimonate	11	1.48	67.2	....
6	Sodium antimonate	9	1.41	64.8	....
5	Sodium antimonate	7	1.44	63.0	....
27	Zirconium silicate B	11	1.48	64.8	....
26	Zirconium silicate B	9	1.48	63.0	....
25A	Zirconium silicate B	7	1.39	60.6	Calcined at 1000 °C
25	Zirconium silicate B	7	1.41	58.2	....
14	Zirconium oxide	9	1.42	65.4	....
4	Zirconium oxide	7	1.39	65.8	....
12	Zirconium silicate A	7	1.38	52.2	....
20	Zirconium silicate A	11	1.33	48.2	....
8	Zinc aluminate	7	1.56	56.3	Calcined at approx. 1200°C
16A	Zinc aluminate	9	1.53	55.7	Calcined 2 hrs. at 1000°C
16B	Zinc aluminate	9	1.35	54.5	$ZnO.Al_2O_3$ not calcined
16D	Zinc aluminate	9	1.31	48.5	$2ZnO.3Al_2O_3$ not calcined

In the case of the first two opacifiers, the opacity is increased as the amount of opacifier is increased. With zirconium silicate A, the opposite seems to be true, and while this may be a property of the material, the reflection value is affected of course by the amount of firing and by the quantity of enamel applied. With zirconium oxide, 7% is apparently as effective as 9%. Since the weight of enamel on the samples varied, no mathematical relation between the total reflection and per cent of opacifier has been attempted.

The data on the zinc aluminate show primarily the effect of treatment and the importance of calcining. The values of total reflection for samples 8 and 16A show apparently that calcination at the higher temperature is equivalent to increasing the per cent of opacifier.

Conclusions

This investigation of substitute opacifiers for tin oxide leads to the following conclusions:

1. Zirconium oxide and sodium antimonate are apparently the best substitutes investigated and are nearly as good as tin oxide itself. Next in order of excellence is the sample of zirconium silicate from dealer B. If either of the first two is used in quantities of about 11% the opacity is strictly comparable with that of 7% of tin oxide. Feldspar opacifier, zinc aluminate and "commercial substitute" in such quantities as used here (7 and 9%) fail to satisfy the requirements for a good opacifier, but may be classed as fair.

2. The opacity does not always increase as the amount of opacifier increases. Apparently an "overloading" is possible which may be deleterious to the opacifier itself.

3. Within certain limits, it is impossible to classify enamels for opacity with accuracy, by merely looking at them. Even the consensus of opinion of several observers does not obviate the possibility of mistakes. If the samples were equally shiny, and of the same color (all blue, all white, or all yellow) such classification would have more value.

4. By determining the spectral reflection curve of an enamel, and from this computing its total reflection for sunlight, an accurate means is provided for determining its relative opacity. This method is free from all errors of personal judgment.

It is to be noted in this connection that primarily the diffuse reflection is involved in these measurements.

5. This investigation is preliminary to further work and it is not to be assumed that the opacifiers included would not give distinctly different results if used in enamels of other compositions.

PART II

Determination of Reflection Values

There are two factors to be considered in the reflection measurements, (1) the light diffusely reflected from the enamel and (2) the light diffusely reflected from the ground coat behind the enamel. The ground coat for these enamels was dark bluish gray and its reflecting power was small compared with that of the enamel itself. As the enamel increases in reflecting power, it decreases in transmitting power, which means that the portion of light getting through to the ground coat also decreases; hence the amount reaching the observer's eye from the ground coat becomes correspondingly smaller. Therefore the reflection of light from the *enamel* is a measure of its opacity. Since the ground coat is seen only by virtue of the light that it reflects, this means of measuring the opacity of the enamel, namely by its reflecting power, seems the logical method. There appears to be no rigid definition of the term "opacity" as employed by enamelers. In these experiments, measurements have been made on the light diffusely reflected from the enamel, together with the very small amount reflected from the ground coat.

If sunlight falls on a diffusing surface that is perfectly white, all of this light will be reflected by the surface—that is the reflection will be 100 per cent. Strictly speaking, this is what is meant by the term "white." Since no substances are known with a reflection equal to 100 per cent, it has become customary to speak of substances with a high reflecting power as white, although in fact they are only "nearly white" or gray. The word has been used in the less technical sense throughout this paper.

This investigation was undertaken originally to examine the enamels from the standpoint of selectivity of color. There are very few so-called "white" materials that do not show some predominating hue—yellow, green, etc. It was thought that a study of these characteristic hues might throw some light on the efficiency of the different opacifiers. The results on total reflection, already recorded in Part I, could have been obtained much more easily with a simple photometer or reflectometer.

Spectrophotometric Apparatus

The *reflection* data were obtained with a König-Martens spectrophotometer, used in connection with an illumination box designed at the Bureau of Standards. The apparatus has been described fully elsewhere[1] and these descriptions are available for those interested in the details of the method. The enamel under test and the magnesium carbonate are placed side by side in a block at the back of the illumination chamber. The radiation

[1] *Ann. der Phys.*, **4** [12], 984 (1903); Bureau of Standards, *Sci. Papers*, **440**, 126 (1922).

from ten tungsten lamps falls on this block and on the walls of the chamber. The light diffusely reflected from the walls of the chamber also falls on the two surfaces, which in turn diffusely reflect it. From most of the enamel samples there is also considerable specular reflection, due to the glaze of the surfaces, but this constitutes only a small percentage of the light reflected to the measuring instrument. It does however affect the appearance of the field and slightly decreases the accuracy of setting.

The spectrophotometer is sighted upon the two surfaces in a direction normal to them through two apertures in the illumination box, so that each half of the photometric field is illuminated respectively by light from the enamel and the magnesium carbonate. The photometric setting consists in making these two halves equal in brightness. Sample and standard are then interchanged in position and the two halves of the field again brought to equality of brightness. Such settings are made at different wave lengths throughout the visible spectrum. The reflection of the sample relative to the magnesium carbonate under the above conditions of illumination and observation, is computed for each of these wave lengths. From the data thus obtained, the reflection curve for the sample is mapped out (Figs. 1 and 2). Since the absolute values for magnesium carbonate are known to be very high (in the neighborhood of 98%), the values given for the enamels are not far from their absolute values.

In order to measure the total light reflected, the values of the sun's luminosity at the different wave lengths are used. This luminosity involves both the spectral energy distribution in sunlight and the sensibility of the eye to light of different wave lengths.[1] The values of the sun's luminosity are multiplied by the reflection values of the sample, wave length by wave length, and from these data the luminosity curve of the sample can then be plotted. These curves have not been reproduced in this report. The area under this curve is measured by a planimeter. The ratio between this area and that of the sun's luminosity curve gives in per cent, for purposes of comparison, the total amount of sunlight reflected.

Results

The results for the samples examined are shown in the form of graphs, Figs. 1 and 2, in which the per cent reflection has been plotted vertically and the wave length horizontally. The points obtained from the spectrophotometer readings are connected by a smooth curve. The per cent of error in these determinations varies by approximately 1 to 2% of the reflection value, depending upon the wave length and upon the condition

[1] The values for the energy of average noon sunlight at Washington, D. C., are Abbot's data as adopted by Priest, see *Phys. Rev.*, **2** [11], 502, Fig. 1; the values of visibility of radiant energy are those adopted by Priest, see Bureau of Standards, *Sci. Papers*, **417**, 236, Fig. 2.

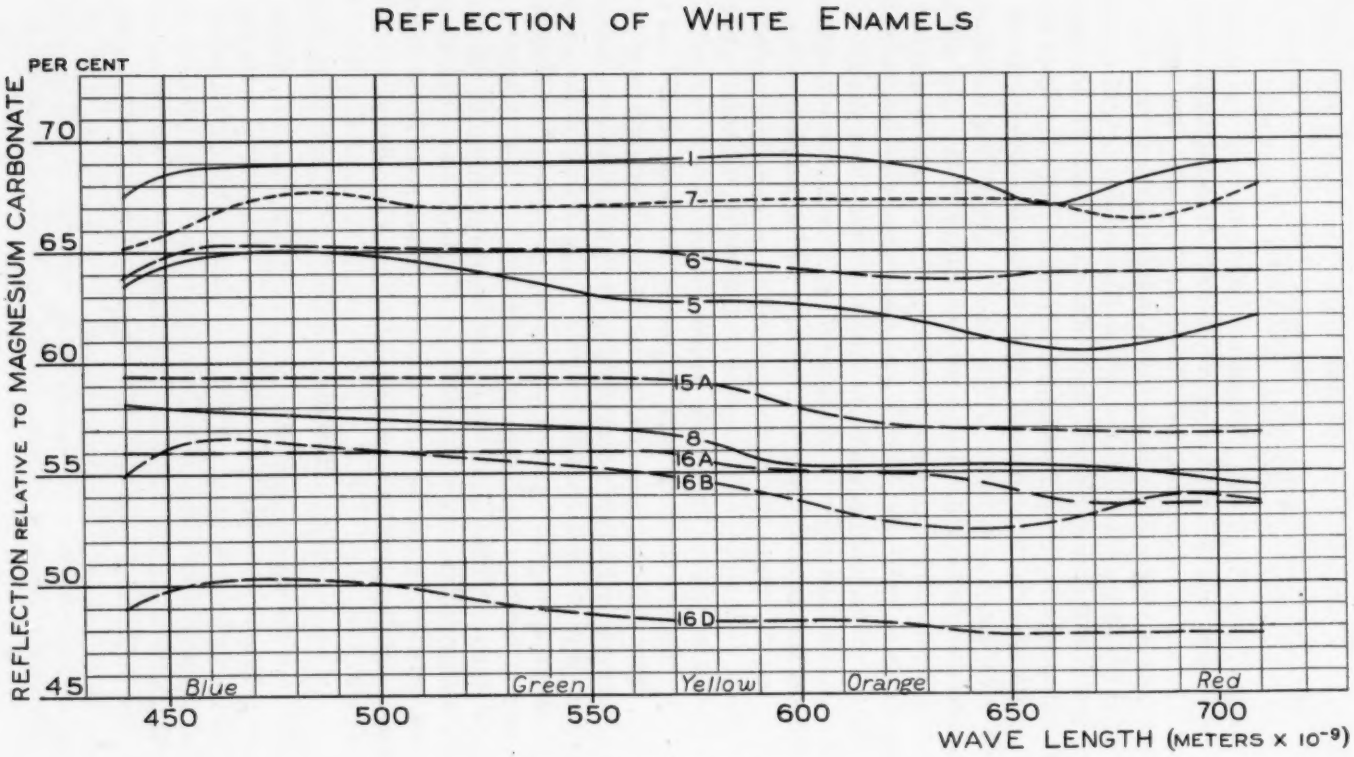


FIG. 1.—Opacifiers for enamels.

No. 1—Tin oxide 7%
No. 7—Sodium antimonate 11%
No. 6—Sodium antimonate 9%
No. 5—Sodium antimonate 7%
No. 15A—Feldspar calcined 9%
No. 16A—Zinc aluminate calcined 9%
No. 8—Zinc aluminate calcined 7%
No. 16B—Zinc aluminate 9%
No. 16D—Zinc aluminate 9%

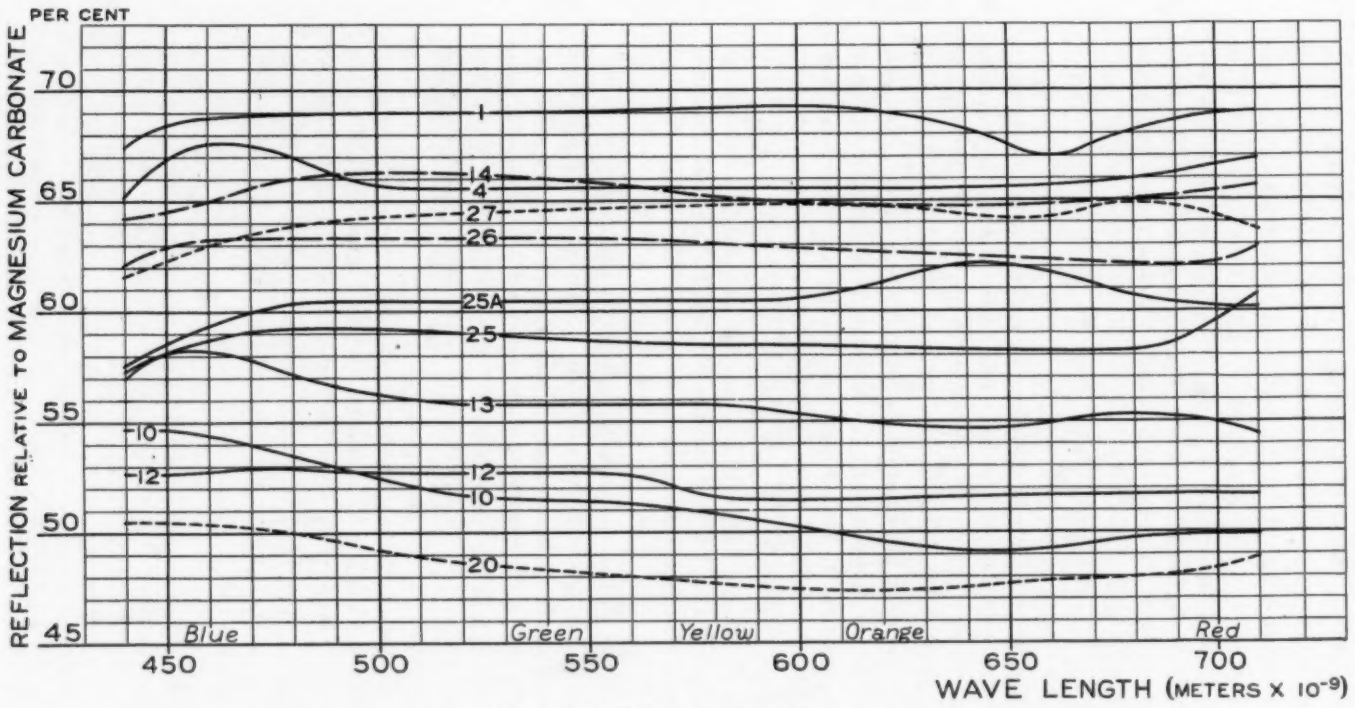


FIG. 2.—Opacifiers for enamels.

No. 1—Tin oxide 7%
No. 4—Zirconium oxide 7%
No. 14—Zirconium oxide 9%
No. 10—Zirconium product 7%
No. 13—Commercial substitute 7%
No. 26—Zirconium silicate B 9%
No. 25—Zirconium silicate B 7%
No. 25A—Zirconium silicate B calcined 7%
No. 12—Zirconium silicate A 7%
No. 20—Zirconium silicate A 11%
No. 27—Zirconium silicate B 11%

of the surface under test. Some of the samples, notably numbers 16A, 20, and 10 had rather poor, non-uniform surfaces and sample 13 had marked defects. The values of reflection given, therefore, cannot always be considered as representative of the sample as a whole, as only a part of it (an area a little greater than 1 sq. inch) is concerned in the measurements.

The spectral reflection of a perfect white or gray material would be represented by a horizontal straight line. Since the specimens examined showed comparatively little selectivity, the use of the terms "white" and "gray" as applied to them is justifiable. Some of the enamels were decidedly gray in appearance and of too low reflection to serve as white enamels. It can readily be seen, however, from the curves that a number of these enamel specimens are slightly selective in color, that is they appear somewhat blue or yellow. This is also apparent to the eye in observing the specimens in sunlight. But from the standpoint of opacity, this small selectivity affords very little information for the following reason: Enamels of the same composition, differing only in amount of opacifier used, or in the calcining temperature, do not always appear the same hue. In Fig. 2, this is particularly noticeable in the zirconium silicate group, No. 27 and 25A are slightly yellowish, No. 26 and 25 are slightly bluish. The yellow hue of No. 25A cannot be with any surety ascribed to calcining, as No. 15A and No. 16A of Fig. 1 do not show a similar effect. Other samples of more pronounced hue must be examined before these points can be settled.

The enamels arrange themselves in order of opacity according to the distance of their curves above the horizontal axis. This furnishes a method of comparing the enamels with each other, and of analyzing the effect on the reflection of the different opacifying materials used. It is readily seen from Fig. 2, for example, that the reflection values for sample No. 1 (tin oxide opacifier) are about 21% better than the reflection values for sample No. 20 (impure zirconium silicate opacifier).

The results on the total reflection of the samples have already been given in Table II. While similar results could be obtained more readily with a reflectometer, the analysis of the spectral reflection could not be determined with this instrument. The need of standard apparatus for making accurate measurements on such materials is again emphasized by the results of this investigation.

BUREAU OF STANDARDS
WASHINGTON, D. C.

THE REVERSIBLE THERMAL EXPANSION OF REFRACTORY MATERIALS

By H. S. Houldsworth and J. W. Cobb

ABSTRACT

The reversible thermal expansion from 15–1000°C was measured for kaolin, siliceous and aluminous fire clays, quartzite, alumina, magnesia, and carborundum, after preliminary burnings at cones 06, 9, 14 and 20, and as well as for English commercial silica bricks before and after use in a coke oven and the roof of a steel furnace. Kaolin and bauxitic fire clay after calcination have a regular reversible thermal expansion which does not vary much with the temperature of calcination. Siliceous fire clays, after calcination at cone 06 (980°C) or cone 9 (1280°C) display irregularities (departures from uniformity) in their expansion. Between 500° and 600°C they show a large expansion due to contained quartz and on cooling the contraction in that region is larger than the corresponding expansion. Moreover, the expansion between 100° and 250°C after being fired to cone 9 (1280°C) exceeds the average. After calcination at higher temperatures, cone 14 (1410°C) or cone 20 (1530°C), these materials gradually lose these peculiarities until on incipient vitrification a linear expansion similar to that of kaolin is attained. This change is due to the destruction of quartz by its interaction with the clay material and fluxes; it takes place most easily in a fine-grained, rather friable clay such as ball clay. The previous thermal treatment necessary for a particular clay in order to obtain regular expansion in use can only be determined by trial. It can be stated with confidence that in such a piece of apparatus as a glass pot or crucible, a distinct gain will result from maintenance at a high temperature for some time before use, but that the red heat of an ordinary pot arch is useless for the purpose. An increase in the porosity of a fire clay was accompanied by a corresponding decrease in expansion between 15° and 1000°C until a porosity of 50% was attained. Further increase in porosity produced very little change in the expansion. No irregularities in expansion were shown by magnesia brick, carborundum, or alumina bonded with 10% of ball clay. Welsh quartzite with lime bond, either unfired or after burning at cone 06, had a large expansion to 550°C and a much larger expansion from 550–600°C due to the inversion of α to β quartz while from 600–1000°C a slight contraction took place. Firing to cone 9 converted part of the quartz into cristobalite, thus increasing the expansion from 200–250°C. This conversion was considerably increased on burning for two hours at cone 14, which greatly reduced the expansion from 550–600°C with a corresponding increase of that from 200–250°C. The conversion of the quartz into cristobalite was completed by a further heating for two hours at cone 20. Determinations of refractive indices and specific gravities confirmed these results. Flint inverted to cristobalite with greater ease than quartz. Commercial silica brick consisted chiefly of cristobalite and unconverted quartz and showed a large expansion up to 300°C, followed by a considerably smaller but regular expansion to 550°C. From 550° to 600°C the rate of expansion was considerably increased, but above 600°C the change in dimensions was small. The innermost exposed layer of a silica brick after use in a coke oven was an impure glass with a steady expansion, but only half as large as that of the layers of brick behind, which was made for shelling away. A silica brick after use in a steel furnace was divided into four layers. The layer exposed to the furnace heat was practically all cristobalite and silicates, the next layer the same, the third layer showed some α to β quartz expansion as well as the α to β cristobalite expansion, while the fourth (outermost) layer exposed to air was similar to the brick before use. In these bricks exposure to high temperature had evidently completed the change from quartz to cristobalite which had been largely effected in the kiln during manufacture. Little or no tridymite had formed.

The reversible thermal expansion from 15–1000°C of the commercial silica brick examined was 1.1 to 1.3%, about double that of fire clay brick.

Introduction

The following paper brings together the results obtained in studying in our laboratory in Leeds the reversible thermal expansion of a number of refractory materials including pure clays, fire clays, bauxites, alumina, carborundum, magnesia and silica; it deals also with the transformations of silica as occurring in various forms of silica and silica refractories. More detail than it was possible to give here can be found in the following papers, where, too, fuller reference is made to the work of others.[1]

The change in volume which occurs on heating is one of the most important physical properties of refractory materials and may at times be decisive in the attainment of success in their application to large scale practice.

The actual change in volume may be due to two factors, the one permanent and usually spoken of as the "after-contraction" or "after-expansion," the other temporary and solely dependent on the temperature and therefore reversible. The work described in this paper was undertaken in order to obtain data of the reversible thermal expansion of refractory materials, a subject which hitherto had not received the attention it deserved.

Apparatus

The apparatus used was similar to that described by Boeck.[2] A silica glass (vitreosil) tube A (see Fig. 1) was heated in a nichrome-wound electrical furnace, the end of the tube projecting from the furnace being attached to a brass tube E. The test piece in the form of a rod 20 cms. long and 2.5 cms. thick was placed inside this silica tube together with silica glass distance pieces C and D of such lengths that the specimen occupied the zone of uniform temperature of the furnace. The distance piece D was cemented to another brass tube F, which could slide between guiding screws within the outer brass tube E. The inner and outer brass tubes each carried a small glass plate marked with a fine scratch. The relative movement of the scratches was observed with a microscope fitted with a micrometer eyepiece and gave the expanison of the test piece relative to

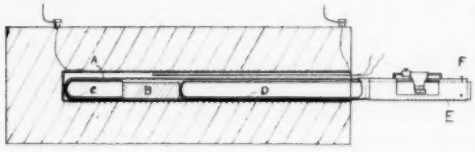


FIG. 1.

[1] For a fuller discussion see *Trans. Soc. Glass Tech.*, **3**, 201–22 (1919); *ibid.*, **5**, 16–44 (1921); *Trans. Eng. Ceram. Soc.*, **21**, 227–76 (1921–22).

[2] *Trans. Amer. Ceram. Soc.*, **14**, 470 (1912).

silica glass, the expansion of which was very small and was accurately known between 15° and 1000°C.[1] One division of the scale of the micrometer eyepiece corresponded with 1114×10^{-6} mm. Temperatures were observed by means of a thermocouple attached to the outer silica glass tube and having its junction about the middle of the specimen.

Results Obtained

(*a*) **Kaolin and Highly Aluminous Clays.**—The expansion curves obtained for kaolin and a highly aluminous (Ayrshire bauxitic) clay (see Fig. 2) were very similar.

Test-pieces fired to cone 06 showed a regular expansion with rise of temperature. The total expansion from 15–1000°C was increased after burning at cone 9, the rate of expansion from 15–200°C being now greater than in any other part of the temperature range. The expansion was slightly decreased by giving the specimen a preliminary firing for two hours at cone 14, the rate of expansion from 15–200°C being still greater than from 200–1000°C. After firing for two hours in a laboratory furnace at 1520–1555°C, resulting in a very close-grained fracture and great reduction in porosity, it was found that the greater rate of expansion from 15–200°C had been removed and that the expansion from 15–1000°C had been considerably reduced. Free quartz was not detected in the expansion of any of these test-pieces.

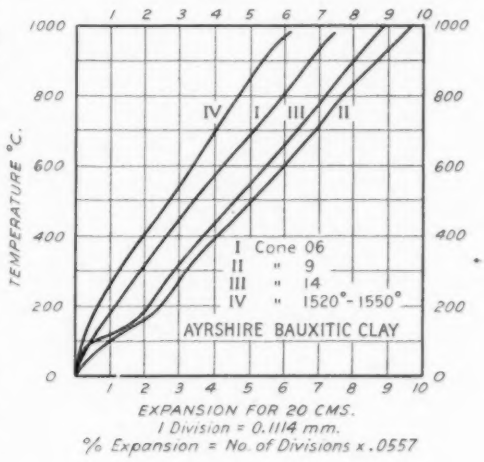


FIG. 2.

(*b*) **Fire Clays Containing Free Silica.**—Farnley (Yorkshire) fire clay (see Fig. 3) was mixed by hand to a fairly soft plastic condition, molded, dried, and burned in a works kiln to cone 06 in forty-eight hours, and to cone 9 in seventy-two hours. The test-piece fired at cone 06 expanded regularly to 550°C but the rate of expansion was considerably increased from 550° to 600°C, due to the volume change associated with the inversion of the free α quartz of the clay to β quartz. The test-piece then expanded regularly to 900°C the rate of expansion from 600° to 900°C being less than from air temperature to 550°C.

After burning at cone 9 the expansion of the clay between 100° and 250° C was about double that given by the cone 06 test-piece. The expansion

[1] Kaye, *Phil. Mag.*, **6** [20], 718 (1910).

from 500–600°C was slightly less than for the latter specimen but the total expansion from 15–1000°C was considerably greater. On examining the cone 9 sample after heating for two hours in a laboratory furnace at cone 14 (1400°C), resulting in a very slight vitrification and fall of porosity, it was found that the expansion between 100° and 250°, 500–600°C, and 15–1000°C were all a little less than before this treatment, but the total expansion to 900°C was still greater than that found for the test-piece fired to cone 06. In each case the contraction on cooling from 600–500°C was greater than the expansion on heating from 500–600°C. This difference between the heating and cooling curves was found for all the clays examined which contained free quartz.

The test-piece was next fired in a laboratory furnace for two hours at 1520–1555°C. On examining the test-piece, which had vitrified to a sugary fracture with a great fall in porosity, a marked change in the temperature-expansion curve was found. The rapid expansions associated with the ranges 100–250°, and 500–600°C had disappeared and the expansion was found to be regular. The small coefficient of expansion which the specimen showed was worthy of note. No free quartz could be detected. Similar results were obtained with the other siliceous clays [Stourbridge, Scottish (Atlas), and Halifax (both before and after experimental electric osmosis)] examined, the heat treatment necessary to remove the α to β quartz expansion being considerably lower for a Dorset ball clay vitrifying at a relatively low temperature. The changes are associated in some way with the process of vitrification and mark, presumably, the disappearance of the quartz by interaction with the clay substance. Microscopic examination of a section of the clay after burning at 1550°C showed the specimen to be a glass with small bunches of radial crystals, probably sillimanite distributed through it. The lowering of the coefficient of expansion noted with fire clays when vitrification had commenced and the quartz effect had been destroyed has its parallel in glazes and glasses. The proportion of unvitrified quartzose silica induces considerable and irregular increases in expansion, but as soon as the silica is brought into complete solution or combination, as, for example, in a clear glass or glaze, the result is a reduction in the coefficient of expansion.

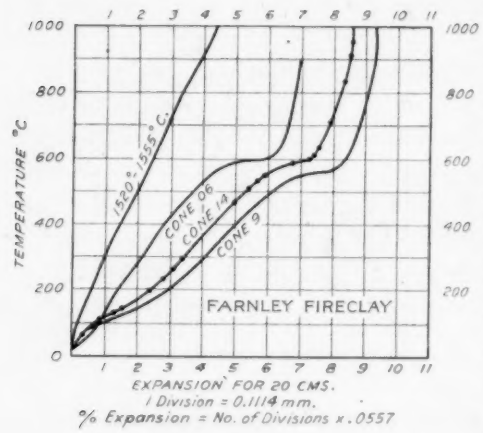


FIG. 3.

(*c*) **Alumina, Magnesia Brick, Carborundum** (see Fig. 4).—The expansion-temperature relationship for alumina (fine-calcined alumina as prepared commercially from bauxite for the manufacture of aluminium and bonded with 10% of ball clay), magnesia brick, and carborundum were all nearly linear and only slightly modified by the variations in preliminary heat treatment. The expansion of carborundum was small and that of magnesia large, while the expansion of alumina was intermediate between those of carborundum and magnesia.

(*d*) **Effect of Porosity on Expansion of Fire Clay.**—Since the expansion of a test-piece must be determined by the degree of effective continuity resulting from the juxtaposition of its constituent particles, it may be expected to be influenced by breaches of that continuity brought about by pores

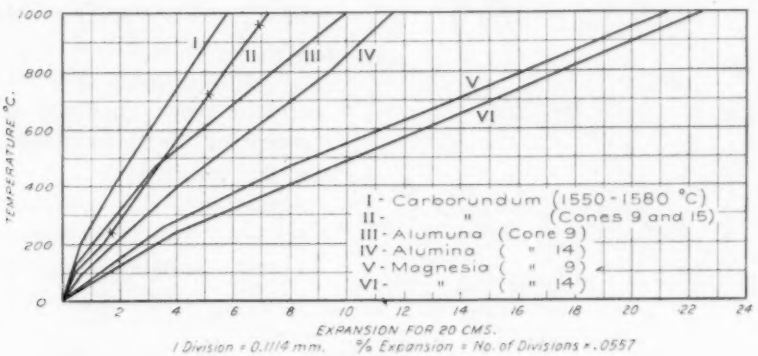


FIG. 4.

in the material. The size and shape of the pores are no doubt of importance, and to give definiteness to the tests we produced differences in porosity by the introduction of combustible grains of one known size.

Farnley fire clay was ground and sieved through a standard 20-mesh (I.M.M.) sieve, and test-pieces were prepared from the clay after mixing with rape seed as uniformly as possible. The specimens were fired in a works kiln, so as to burn out the seed and leave pores. The average volume of the rape seeds used was 0.00287 cc., corresponding with a diameter of 0.176 cm.

The porosity[1] of the test-piece made from the clay without the addition of rape seed was 28.7% and its coefficients of expansion were as follows:

15–500°	769×10^{-8}	600–1000°	183×10^{-8}
500–600°	1275×10^{-8}	15–1000°	583×10^{-8}

A test-piece prepared as described above, and having a porosity of 44.6%,

[1] That is, percentage volume occupied by open pores.

showed, as was anticipated, a smaller expansion (see Fig. 5) its coefficient of expansion for the various ranges being:

15–500°	602×10^{-8}	600–1000°	281×10^{-8}
500–600°	1053×10^{-8}	15–1000°	517×10^{-8}

A specimen with a porosity of 50.2% had a still smaller expansion, giving values of:

15–500°	550×10^{-8}	600–1000°	295×10^{-8}
500–600°	997×10^{-8}	15–1000°	491×10^{-8}

A further increase in porosity did not produce any measurable change in expansion, a test-piece of porosity 58.0%, giving results practically identical with those obtained for the specimen with a porosity of 50.2%. The results are shown graphically in Fig. 5.

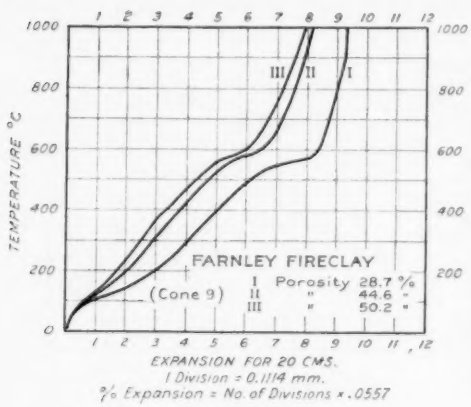


FIG. 5.

It thus appears that up to a certain point (namely, a porosity of 50%) increased porosity resulted in a decreased expansion, although in one range (600–1000°C)there was actually a slight increase in expansion with increasing porosity.

(*e*) **Quartzite** (see Fig. 6).—A Welsh (Bwlchgwyn) quartzite was ground and sieved through a standard (I.M.M.) 20-mesh sieve, 3% of plaster added as slip and dried. A test-piece was examined in the expansion apparatus without being submitted to any preliminary burning. It had a large coefficient of expansion from 15–600°C owing to the inversion of α to β quartz. From 500–750°C practically no further change in dimensions was detected and the specimen contracted slightly from 750–1000°C. A test-piece which had been fired in a works kiln to cone 06 gave a similar expansion-temperature graph, but the expansion between 550° and 600°C was less than that for the unfired sample. Determinations of density and refractive indices showed, however, that this result could not be attributed to any conversion of the quartz into other modifications of silica. The greater expansion of the unfired specimen was due to the permanent expansion of the test-piece on firing, which was superimposed on the ordinary reversible thermal expansion, the difference in the expansion of the cone 06 and unfired specimens being approximately the same as the permanent expansion shown by the latter on heating to 1000°C. This permanent expansion is due not to the conversion of quartz into the

lower density forms of silica, but to an increase in the porosity of the sample, a result which as studied in more detail for Meanwood ganister which had a larger permanent expansion (about 0.7%) on first heating to 1000°C. It was found that practically no change in specific gravity or refractive index had taken place but the porosity had increased from 14.4% to 17.0%.

The temperature expansion curve for the quartzite burned to cone 9 (Fig. 6, curve C) in a works kiln was very different. The test-piece expanded steadily to 150°C but from this temperature to 250°C a much greater rate of expansion was noted. From 250° to 550°C the rate of ex-

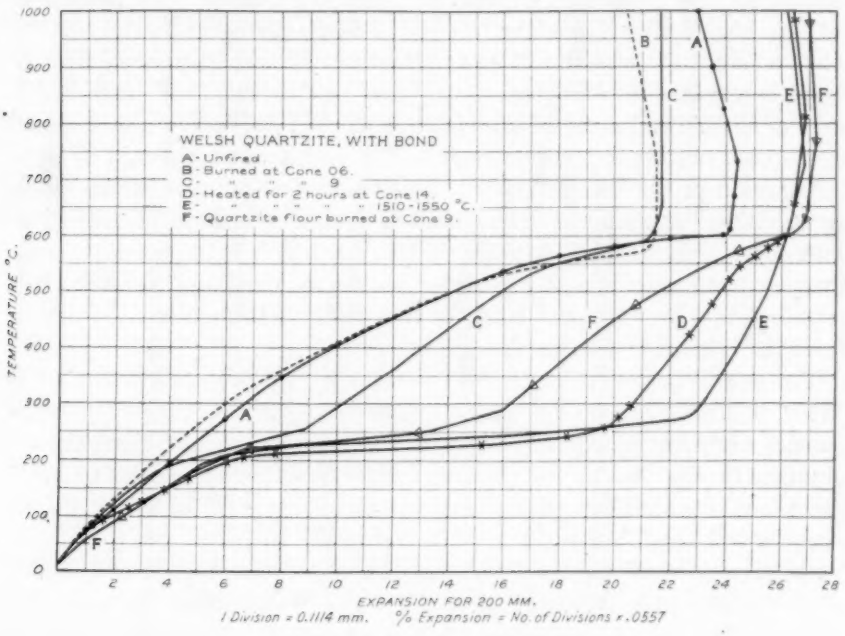

WELSH QUARTZITE, WITH BOND
A - Unfired
B - Burned at Cone 06.
C - " " " 9
D - Heated for 2 hours at Cone 14
E - " " " " 1510 - 1550 °C.
F - Quartzite flour burned at Cone 9.
TEMPERATURE °C.
EXPANSION FOR 200 MM.
1 Division = 0.1114 mm. % Expansion = No. of Divisions × .0557

FIG. 6.

pansion was again smaller, but a large increase in the rate was observed from 550° to 600°C. From 600° to 1000°C there was practically no increase in dimensions. The cooling curve nearly coincided with the heating curve so that the abrupt changes in length at 150° to 250°C and 550° to 600°C were reversible and were evidently due to the inversion of α to β cristobalite, and of α to β quartz, respectively. The actual expansion to 1000°C was the same as for the test-piece fired to cone 06. The specific gravity of the quartzite had decreased to 2.58, while the index of refraction of all the material was greater than 1.481 and of nearly all greater than 1.503, indicating quartz mixed with a small amount of cristobalite, results

which were in agreement with the changed character of the expansion curve.

The specimen was next fired in the laboratory for two hours at cone 14, which produced a permanent expansion of 2.6%. It was again examined in the expansion apparatus (see Fig. 6, curve D). The length increased regularly up to 200°C but from 200° to 250°C an extremely rapid expansion occurred amounting to 0.75% of the original length of the test-piece. From 250° to 550°C the sample expanded regularly, but from 550° to 600°C there was the usual rapid rate of expansion always observed with quartz. The quartz expansion, was, however, only about one-third of that noted after burning at cone 9. A slight expansion took place from 600° to 800°C after which the test-piece contracted slightly to 1000°C. The cooling curve was almost identical with the heating curve so that the rapid expansions noted between 550° and 600°C and 200° and 250°C were reversible and must be associated with the inversion of α to β quartz and α to β cristobalite, respectively. This result was supported by a determination of the specific gravity which was 2.35, a value which would agree with a large amount of cristobalite (specific gravity 2.33) associated with some quartz (specific gravity 2.65). A microscopic examination of the powdered specimen showed it to consist of a mixture of quartz and cristobalite. No tridymite could be detected, all the material having an index of refraction greater than 1.481.

The test-piece was next fired for two hours in a laboratory furnace at 1510° to 1520°C (cone 20) and its expansion again determined. The expansion-temperature curve (Fig. 6, curve E) was practically along the one obtained for the cone 14 test-piece up to 200°C but from this point to 250°C there was a somewhat greater expansion. From 250° to 550°C the expansion was small but regular, while from 550° to 750°C the rate of expansion was smaller. No rapid expansion between 550° and 600°C could be detected, indicating the absence of quartz from the specimen. From 750° to 1000°C a slight contraction was noted. The rapid expansion between 200° and 250°C was again reversible and was due to the α to β cristobalite inversion. It would seem that the whole of the quartz had been converted into cristobalite, a result which was confirmed by the specific gravity which had become 2.33. The refractive index of all save one or two grains was between 1.481 and 1.503 so that the microscopic examination also showed that the quartzite had been converted completely into cristobalite, the few grains with index of refraction greater than 1.503 probably being silicates.

Summarizing, the quartzite on burning to cone 06 showed only a small permanent expansion and was still unconverted quartz. Firing to cone 9 converted part of the quartz into cristobalite, the conversion being considerably increased on burning for two hours at cone 14, and completed

after a further heating at cone 20 for two hours. No evidence of the conversion of the quartzite into tridymite was observed. The conversion of the quartz into cristobalite brought about a larger expansion from 15° to 1000°C after burning at cone 14 or cone 20 than after firing to cone 06 or cone 9. By far the greater part of the expansion, however, had been brought into the range 15° to 300°C the increase in length being small between 300 and 1000°C. This result bears distinctly on furnace practice. With bricks in which the quartz had been converted into cristobalite by hard firing, no strain and danger of fracture would result from fluctuations of temperature between 1000° and 300°C after the temperature of 300°C had been once attained, whereas with lighter burned bricks containing quartz strain would result whenever the temperature fell below 600°C. The large and rapid expansion up to 300°C for the material fired to cone 14 and upwards emphasized, however, the necessity for slow and careful heating in the initial period of heating if expansion strains were to be avoided.

Flint behaved very similarly but was converted into cristobalite with greater ease, no quartz remaining after the test-piece had been heated at cone 13–14 for two hours. A local (Meanwood) ganister inverted much more slowly . . . . . .

(*f*) **Commercial Silica Brick.**—So far only specially prepared specimens had been used. Experiments were next conducted on commercial silica brick, two of them being made from the Welsh quartzite we had studied by kilning at about cone 16. Silica brick of the same manufacture were also examined after use in coke ovens and steel furnaces so that the effect of long industrial heating could be studied.

Sample A (see Fig. 7, curve A).—The first brick examined was one made from Welsh quartzite (Bwlchgwyn). A test-piece was cut from the actual brick and examined. A very large coefficient of expansion was observed from 15° to 250°C followed by a considerably smaller but regular expansion to 550°C. From 550° to 600°C the rate of expansion was considerably increased. A small coefficient of expansion was found between 600° and 750°C, and from this temperature to 1000°C there was a slight contraction. The large expansion up to 250°C could be associated with the transformations of tridymite and cristobalite, while the increased rate of expansion from 550° to 600°C would correspond with the inversion of α-quartz into β-quartz. It was apparent that the burning of the brick in the kiln had caused the transformation of a large part of the quartz into other forms of silica. The large expansion caused by the low temperature inversion of the cristobalite present in the silica brick caused the expansion of the brick from 15° to 1000°C to be more than double that for a fireclay brick. It would demand slow and careful heating with no rigid ties when the structure was first heated, and would be a source of danger from

cracking and opening-out of the brickwork if the furnace had to be let down below 300°C. The contraction would then need following up carefully with the ties. The specific gravity of the brick was 2.40. Microscopic examination of the powdered brick showed it to be a mixture of quartz and cristobalite with only a trace of tridymite.

Sample B (Fig. 7, curve B).—This was cut from a commercial brick prepared from the same quartzite as sample *A*, but containing 25% of quartzite flour (98% passing through a 200-mesh sieve). Its expansion temperature curve was of the same form as that for sample *A* but its ex-

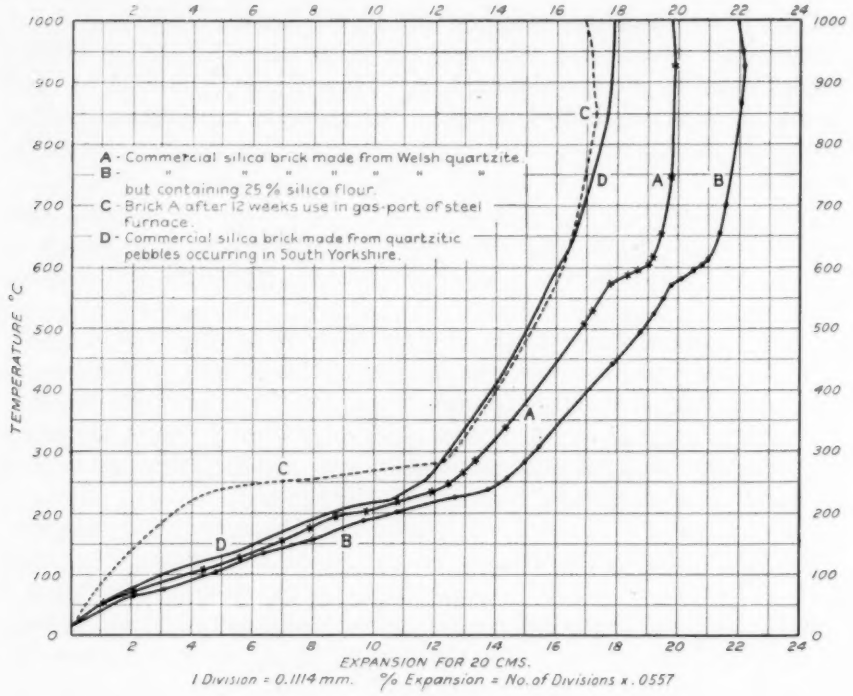

A - Commercial silica brick made from Welsh quartzite.
B - " " " " " " "
but containing 25 % silica flour.
C - Brick A after 12 weeks use in gas-port of steel furnace.
D - Commercial silica brick made from quartzitic pebbles occurring in South Yorkshire.
TEMPERATURE °C
EXPANSION FOR 20 CMS.
1 Division = 0.1114 mm. % Expansion = No. of Divisions x . 0557

FIG. 7.

pansion from 15° to 250°C was greater and that from 550° to 600°C less. This was observed for the brick made without the addition of quartzite flour.

Sample C (Fig. 7, curve D).—This brick was made from quartzitic pebbles occurring near Bawtry (Yorkshire). We have made no expansion tests on the raw material from which it was manufactured. The expansion of a test-piece cut from this brick was very similar to those of the previous specimens up to 550°C, *i. e.*, it showed a large expansion to 250°C such as might be explained by the cristobalite inversion and a regular but smaller

rate of expansion from 250° to 550°C. At this stage a remarkable and unexpected difference was observed, for no discontinuity between 550° and 600°C such as had always been noted in the case of free quartz was detected. Instead, the brick expanded fairly regularly to 900°C after which there was no further expansion to 1000°C. Apparently all the quartz had been converted into other forms of silica. The large expansion from 15° to 25°C would be explained by the presence of tridymite and cristobalite. The specific gravity of the brick was 2.35. Determinations of

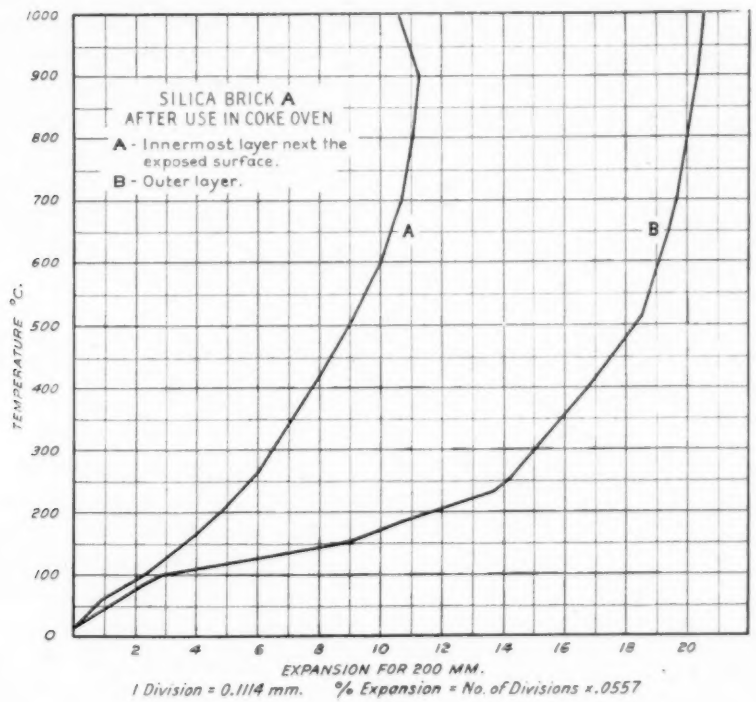


FIG. 8.

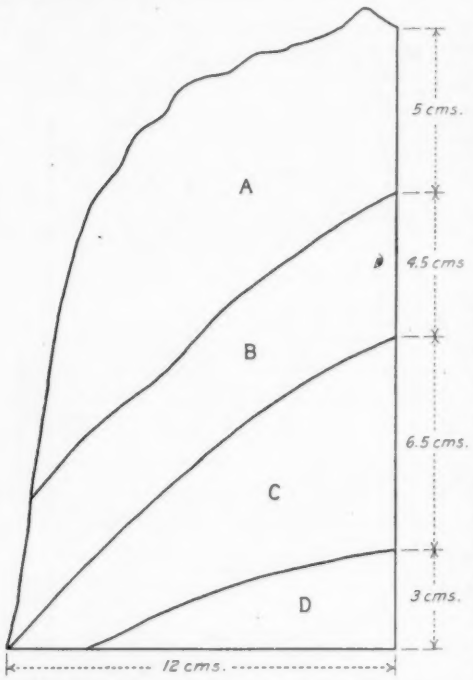
the refractive indices of the particles of the powdered brick showed it to consist chiefly of cristobalite mixed with a very small amount of tridymite and some material of refractive index greater than 1.503 probably silicates. No quartz could be detected in a microsection cut from this brick.

Silica Brick after Use in a Coke Oven

A silica brick of the same manufacture (see Fig. 8) as sample *A* was examined after fourteen months' service at a probable maximum temperature of 1450°C, in a coke oven. On dividing the brick four fairly distinct layers were noted. The innermost layer next the exposed face was

grayish black with large white grains clearly distinguishable, and a brownish black outer crust. This layer was about six-tenths of an inch thick, and was followed by about a one-inch layer of light brown material. The next layer was dark brown and was about one and one-half inches thick, and was succeeded by a light brown layer about one inch thick. This last part looked very much like unaltered brick.

The expansion curve obtained for the material from the innermost grayish black layer showed none of the breaks which we were accustomed to get from material containing quartz, cristobalite, or tridymite. The coefficient of expansion diminished slowly and continuously as the temperature rose. It was such as might be expected from a contaminated quartz glass and the total expansion from 15–1000°C was only one-half that of the layers behind it. The composition of the material in the layer can be expressed empirically by the formula RO; .4 Al_2O_3; 14.3 SiO_2. The outer crust which was obviously partially fused was, no doubt, richer in basic material including ferric oxide. The expansion temperature curves obtained for the other three portions of the brick were practically identical, and the actual expansion from 15° to 1000°C was in each case almost the same as that obtained for the unused silica brick. The character of the curves, however, was somewhat different from that given by the unused brick. There was a rather more rapid expansion from 15° to 150°C and practically no sudden expansion at 550° to 600°C. Above 600°C also the specimens continued to expand whereas the unused silica brick contracted slightly above 700°C. It would seem that the long heating to which the brick had been subjected had completely transformed the original quartz of the brick. The refractive index of the material of these



SECTION OF BRICK FROM ROOF OF STEEL FURNACE
A - Innermost layer next the face exposed in the furnace. Grey to slaty black; honeycombed; vitrified. White grains not seen.
B - Second layer. Black to dark grey with a few large white grains. Semi-vitrified and honey-combed.
C - Third layer. Light grey with large white grains and specks of yellow.
D - Fourth layer. Reddish in color.

FIG. 9.

layers was nearly all less than 1.503 and nearly all greater than 1.481 so that microscopic examination showed them to be cristobalite associated with a little tridymite and quartz or silicates of higher refractive index. The difference in the expansion between the outer darker portions and the remainder of the brick demonstrated one cause of wearing of the brick in use. The expansion from 15° to 1000°C of this darker layer was only about one-half that of the rest of the brick, so that fluctuations of temperature would cause great strain to be set up between these two parts of the brick, with the consequent cracking off of the inner darker layer.

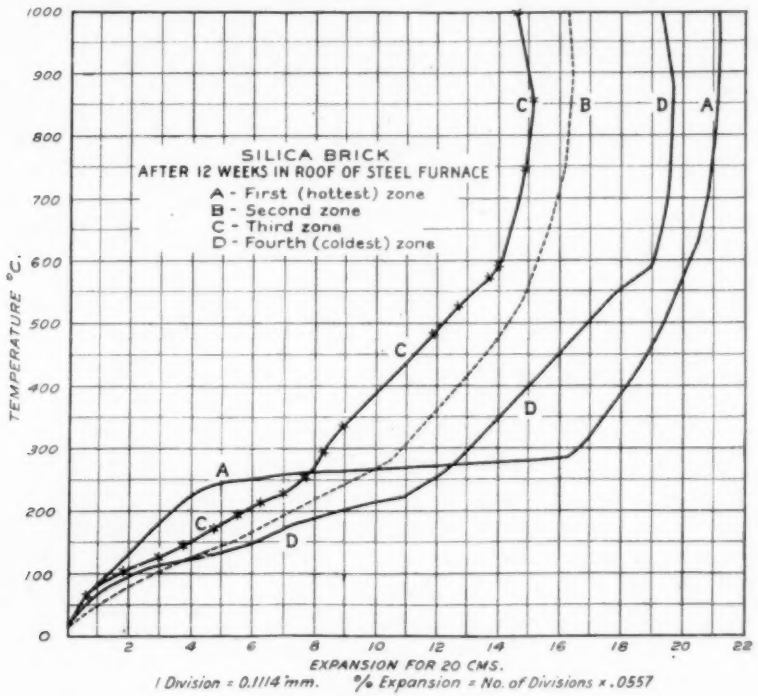


FIG. 10.

Silica Brick after Use in the Roof of a Steel Furnace

Commercial silica brick made from the Welsh quartzite used in this investigation were examined "after twelve weeks' use at a probable maximum temperature of 1600° to 1650°C in the roof of an open hearth steel furnace." On splitting each brick showed four fairly distinct layers (see Fig. 9).

(*a*) **Innermost Layer Next the Face Exposed in the Furnace and Highest in Temperature.** (Fig. 10, curve A.)—A test-piece was cut from this layer of the brick and examined in the apparatus. It expanded

steadily from 15° to 240°C but from this point to 280°C a large and rapid expansion took place so that the temperature-expansion graph was almost parallel to the expansion axis. From 280° to 630°C the rate of expansion was less than from 15° to 240°C. No discontinuity in the expansion was detected at 550° to 600°C such as would be expected if free quartz was present. The coefficient of expansion above 630°C continually decreased until no further expansion occurred between 900° and 1000°C. The large expansion from 240° to 280°C was reversible on cooling but occurred at a lower temperature (220° to 200°C). It was presumably due to the α to β cristobalite inversion. Apparently neither quartz nor tridymite were present in quantity. Microscopic examination showed that the bulk of the material was cristobalite having a refractive index between 1.503 and 1.481. About one-eighth of the powder had an index of refraction greater than 1.503 and probably consisted of silicates. A small quantity had a refractive index less than 1.481 and was probably tridymite.

TABLE I

CHEMICAL ANALYSES OF THE MATERIALS EXAMINED

	Raw kaolin	Raw Farnley fire clay	Ayrshire bauxitic clay	Calcined alumina +10% ball clay	Magnesia brick	Welsh quartzite without bond	Silica brick A	Silica brick C	Silica brick A after use in coke oven, 1st innermost layer
Hygroscopic moisture	0.14	..	0.75	..	..	..	..	..	..
Loss on ignition	12.78	9.36	13.96	..	..	0.26	..	..	0.11
Silica (SiO_2)	46.20	63.48	36.65	5.4	5.80	98.78	93.79	94.24	87.21
Alumina (Al_2O_3)	38.49	22.39	43.83	94.2	1.75	0.12	1.56	1.32	4.16
Titanium dioxide (TiO_2)	..	1.10	3.20	..	..	0.12	0.12	0.25	0.27
Ferric oxide(Fe_2O_3)	0.85	1.33	0.67	0.13	9.71	0.91	1.30	1.69	3.0
Lime (CaO)	0.30	0.70	0.49	0.01	2.15	0.08	3.07	1.79	3.36
Magnesia (MgO)	0.19	0.52	0.00	0.01	79.92	Tr.	Tr.	0.04	0.01
Soda (Na_2O)	0.81	0.88	0.57	0.01	..	0.27	0.15	0.63	1.09
Potash (K_2O)	0.65	0.47		0.01	..				1.35

Second Layer of Brick Used in Roof of Steel Furnace.—This part of the brick expanded quite differently from the hottest portion. (Fig. 10, curve B.) Its length increased steadily and at a fairly rapid rate to 300°C, after which the rate of expansion decreased gradually with increasing temperature until there was a slight contraction between 900° and 1000°C. The cooling curve was similar to the heating curve. No marked discontinuity occurred. The total expansion to 1000°C was about four-fifths, and that from 15° to 300°C about three-fifths, of that of the hottest layer, again showing the possibility of strains and cracks developing owing

to the different rates of expansion of the two layers. Examination of the powdered sample showed about half the material had a refractive index greater than 1.503, that of the other half being between 1.503 and 1.481. A very few particles had a refractive index less than 1.481 and were prob-

TABLE II

POROSITY AND BULK AND FINE SPECIFIC GRAVITIES OF THE MATERIALS TESTED

$$\left(\text{Porosity} = \frac{\text{Wt. of paraffin absorbed by specimen}}{\text{Loss in wt. of saturated specimen on weighing in paraffin}}\right)$$

$$\left(\text{Bulk specific gravity} = \frac{\text{Wt. of specimen}}{\text{Total volume of specimen}}\right)$$

	Temp. of previous burning	Porosity	Bulk sp. gr.	True sp. gr.
Kaolin	Cone 06	47.4	..	..
	Cone 9	34.6	..	..
	Cone 14	23.0	..	..
	Cone 20	0.4	..	..
Farnley fire clay	Cone 06	31.7	..	..
	Cone 9	28.7	..	..
	Cone 14	25.8	..	..
	Cone 20	1.4	..	..
Ayrshire bauxitic clay	Cone 06	30.7	..	..
	Cone 9	28.4	..	..
	Cone 14	26.9	..	..
	Cone 20	4.2	..	..
Magnesia brick	Cone 06	33.9	..	..
	Cone 9	33.9	..	..
	Cone 14	27.8	..	..
Carborundum with clay bond	Cone 20	31.9[1]	.	..
Alumina	Cone 9	72.1	..	..
Welsh quartzite with bond	Unfired	..	..	2.64
	Cone 06	34.4	1.68	2.63
	Cone 9	36.6	1.62	2.58
	Cone 14	39.7	1.43	2.35
	Cone 20	44.7	1.28	2.33
Silica brick A	.....	26.0	1.78	2.40
Silica brick B	.....	26.8	1.76	2.40
Silica brick C	.....	27.9	1.68	2.35
Silica brick A after use in coke oven				
1st (next the exposed face) layer	.....	20.6	1.89	2.37
Second layer	.....	29.0	1.67	2.33
3rd layer	.....	29.6	1.62	2.30
4th layer	.....	30.1	1.59	2.28
Silica brick A after use in roof of steel furnace				
1st (hottest) layer	.....	8.6	2.24	2.45
2nd layer	.....	7.3	2.27	2.45
3rd layer	.....	5.3	2.19	2.32
4th layer	.....	28.1	1.72	2.39

[1] Blistered

ably tridymite. Thus microscopic examination indicated that almost half the material in this layer was cristobalite while the other half had a refractive index greater than 1.503. As no quartz was detected in the expansion test the latter portion was probably chiefly silicates. A very small amount of tridymite was also present.

Third Layer of the Brick Used in Roof of Steel Furnace. (Fig. 10, curve C.)—The total expansion from 15° to 1000°C of the third layer was not very different from that of the second layer but the form of the curve was somewhat different and there was evidence of the α to β quartz inversion. The microscopic examination of the powdered material gave similar results to those obtained for the second layer, but taking these in conjunction with the expansion of the test piece it seemed probable that some quartz and less silicates were present along with cristobalite in quantity.

Fourth Layer of Brick Used in Roof of Steel Furnace. (Fig. 15, curve D.)—The expansion of this test piece did not differ appreciably from that of the unused brick, and microscopic examination of the powdered material immersed in oils of known refractive indices also gave similar results to those obtained for the unused bricks, *i. e.*, this layer consisted of a mixture of quartz and cristobalite with a very small amount of tridymite.

The volume changes in manufacture and use of a silica brick may therefore be traced thus.

First, on burning, the quartz undergoes a permanent linear expansion, with little or no decrease in specific gravity, but an increase in porosity. This permanent expansion may be about one-half per cent even below 1000°

TABLE III

COEFFICIENTS OF EXPANSION $\times 10^{-7}$

Substance	Temp. range (°C)	Temperature of prior firing: Unfired	Cone 06	Cone 9	Cone 14	Cone 20
Kaolin	100–250	...	..	76.4	57.8	..
	15–1000	...	40.2	53.1	47.7	44.1
Farnley fire clay	100–250	...	..	102.3	87.5	..
	15–500	...	48.1	76.9	67.6	..
	500–600	...	133.1	127.5	107.5	..
	600–1000	..	21.7	18.3	25.0	..
	15–1000	...	49.1	58.3	54.0	30.5
Ayrshire bauxitic clay	100–250	...	..	72.6	65.2	..
	15–1000	...	48.0	60.5	56.1	41.8
Carborundum	15–1000	...	..	47.1	47.8	38.6
Magnesia brick	15–1000	...	127.4	127.4	135.1	..
Welsh quartzite with lime bond	15–1000	136	122	128	155	153
	15–500	163	172	192	279	298
	200–250	...	..	396	1454	1721
	500–600	579	417	289	139	44
	600–1000	−4	−4	14	11	7

TABLE III (*Continued*)

COEFFICIENTS OF EXPANSION × 10^{-7}

Substance	Temp. range (°C)	Unfired	Temperature of prior firing: Cone 06	Cone 9	Cone 14	Cone 20
Silica brick A	15–1000	...	118	..	..	..
	15–250	...	304	..	..	..
	250–500	...	101	..	..	..
	500–600	...	127	..	..	..
	600–1000	...	17	..	..	..
Silica brick B	15–1000	...	131	..	..	..
	15–250	...	344	..	..	..
	250–500	...	108	..	..	..
	500–600	...	111	..	..	..
	600–1000	...	23	..	..	..
Silica brick C	15–1000	...	107	..	..	..
	15–250	...	280	..	..	..
	250–500	...	84	..	..	..
	500–600	...	61	..	..	..
	600–1000	...	31	..	..	..
Silica brick A after use in coke oven						
(*a*) Innermost layer	15–1000	...	65	..	..	..
(*b*) Other layer	15–1000	...	121	..	..	
	15–250	...	340	..	..	..
Silica brick A after use in roof of steel furnace						
(*a*) Innermost (hottest) layer	15–1000	...	125	..	..	..
	200–300	...	746	..	..	..
(*b*) Second layer	15–1000	...	98	..	..	..
	15–250	...	231	..	..	..
(*c*) Third layer	15–1000	...	88	..	..	..
	100–250	...	232	..	..	..
	250–500	...	106	..	..	..
	500–600	...	117	..	..	..
	600–1000	...	13	..	..	..
(*d*) Fourth (coldest) layer	15–1000	...	115	..	..	..
	100–250	...	369	..	..	..
	250–550	...	117	..	..	..
	550–600	...	139	..	..	..
	600–1000	...	12	..	..	..

× 220–270°C

C and two per cent up to cone 9. The toughness may appreciably alter in consequence. The further burning to cone 14–16 alters the expansion curve changing the quartz completely or partially according to the nature of the raw material and the time and temperature of burning into cristobalite. This means that the sudden α to β quartz expansion between 500° and 600°C is replaced by the α to β cristobalite expansion between 200° and 300°C. The total reversible expansion is not lessened. The furnace of "cristobalite" bricks is therefore much less subject to expansion strain

at dull redness than one of "quartz" bricks, although more so below 300°C. Neither is at all sensitive above 600°C. Long exposure in use at high temperatures completes the conversion of quartz to cristobalite. Apart from actual test in the expansion apparatus, we have found that a determination of the true specific gravity of the powdered brick is the best guide to its behavior as regards expansion and contraction.

(Specific gravity of quartz = 2.65)
(Specific gravity of cristobalite = 2.33)

The chemical analyses of the materials examined are given in Table I, the porosity of the test-pieces and the specific gravity of the silica specimens in Table II, and their coefficients of expansion in Table III.

FUEL DEPARTMENT
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REFRACTORY POSSIBILITIES OF SOME GEORGIA CLAYS[1]

By R. T. Stull[2] and G. A. Bole[3]

Introduction

Of the different raw materials used in the manufacture of refractories, clay must be relied upon in the future, as in the past, to furnish the bulk of commercial refractories because of its greater abundance, wider distribution, and broader application.

It has been stated[4] that the best fire clays of Pennsylvania, Maryland, Ohio, and Kentucky, within reach of railroads, are waning rapidly and that the average quality of the fire clay refractories classed as number one has fallen off within the last 15 to 20 years. It must, of course, be recognized that there are fire clay refractories on the market at the present time as good as any made in the past, but the bulk of such, as a class, has evidently decreased in refractoriness from one to as much as three cones.

Several plants have experienced difficulty in finding sufficient available flint clay of good quality to supply their needs, while others have exhausted their number one plastic clay and have been compelled to use bond clays of lower refractory value.

The Ohio Geological Survey in coöperation with the United States Bureau of Mines has completed an investigation of the fire clays of the State.[4] Of 86 clay samples tested, mostly from the mines of operating plants, only 16 samples were sufficiently refractory to soften at or above cone 31, thus qualifying as suitable clays for the manufacture of high duty refractories. Twelve of these were flint clays and four were semi-flint. The most refractory ones softened at cone 33 and no bond clays were found in the State of sufficient refractoriness to fall within the high-duty class. The nearest to it were two plastic clays deforming at cone $30^1/_2$.

It was also found that some plants were bonding their high-grade flint clays with plastic clays deforming at cone 29 down to as low as cone 23. Bleininger and Brown have pointed out that a fire brick under load at furnace temperatures[5] is no better than its bond.

The broader application of the electric furnace to the metallurgical and chemical industries, the development of new processes, automatic stoker-fired boilers and the broader application of forced draft to furnaces have created a demand for a more serviceable fire brick of higher refractory value. Such a brick can be made from kaolins and highly aluminous clays.

[1] Published by permission of the Director, U. S. Bureau of Mines.

[2] Supervising Ceramist, U. S. Bureau of Mines.

[3] Superintendent, Ceramic Experiment Station, U. S. Bureau of Mines.

[4] "Coal Formation Clays of Ohio," *Bulletin*, **26**, Ohio Geological Survey. (In press.)

[5] A. V. Bleininger and J. H. Brown, *Trans. Amer. Ceram. Soc.*, **12**, 341 (1910).

Economic Factors

Through the middle of Georgia from Northeast to Southwest runs a belt, known as the coastal plain, 220 miles long and from 25 to 50 miles wide, containing secondary kaolins, bauxitic clays and bauxites in abundant quantities.

These clays were derived from the decomposition of crystalline rocks of the Piedmont Plateau to the North and were washed down and deposited on the coastal plain where beds were formed from a few feet to over 40 feet in thickness.

Nature evidently conducted a clay-washing process on an enormous and efficient scale, for many of these clays are snow-white, very fine grained and comparatively free from impurities. All are very refractory.

The theory has been advanced that bauxites were derived from the alteration of the kaolins. This is indicated by the fact that deposits occur varying in composition all the way from kaolin on the one hand to bauxite on the other.

Many of the fine white clays are produced for the filler trade and several of the white burning ones are used for pottery making purposes.

The kaolins are plastic and mold readily and many of them show a fairly good dry tensile strength. As the alumina content of the clays increases above the kaolinite ratio, their plasticity and slaking tendency decrease and, with rare exceptions, their iron content increases with the alumina. Kaolins and bauxitic clays, which may not be suitable for fillers or pottery, fuse at a very high temperature and, therefore, are valuable for the manufacture of refractories.

Bleininger and Brown[1] point out the advantage of using the same clay for grog and bond, as follows:

"As to fire brick made from a clay material which is sufficiently plastic so as to be used alone, it is clear that its ability to carry loads depends simply upon its composition. Some of the very best tests have been obtained on materials of this kind.....Such a clay will stand up or fail by virtue of its own quality. A pure clay of moderate plasticity would be the ideal material for the manufacturing of fire brick."

The Central of Georgia Railway Company entered into a coöperative agreement with the Bureau of Mines to investigate the pottery making, filler, and refractory properties of the kaolins, bauxitic clays, and bauxites along the Railway's right of way.

Thirty samples of from 500 to 2,000 pounds each were selected in a manner to represent the different types in the field. Some of these clays were found to be valuable for pottery making purposes, while others were especially suited to the filler trade. They were all refractory. The de-

[1] *Loc. cit.*

formation temperatures of the clays tried out for use in the ceramic field varied from cone 33 as the lowest to cone 39 plus for the highest. Of these clays,

2 Samples deformed at cones 33 to 34
14 Samples deformed at cones 34 to 35
3 Samples deformed at cones 35 to 36
1 Sample deformed at cones 36 to 37
3 Samples deformed at cones 38 to 39
1 Sample deformed above cone 39

In the fire brick industry, most of the flint and plastic fire clays are obtained by underground mining. Often it is necessary to move considerable inferior clay to obtain the desirable refractory clay. Underground mining

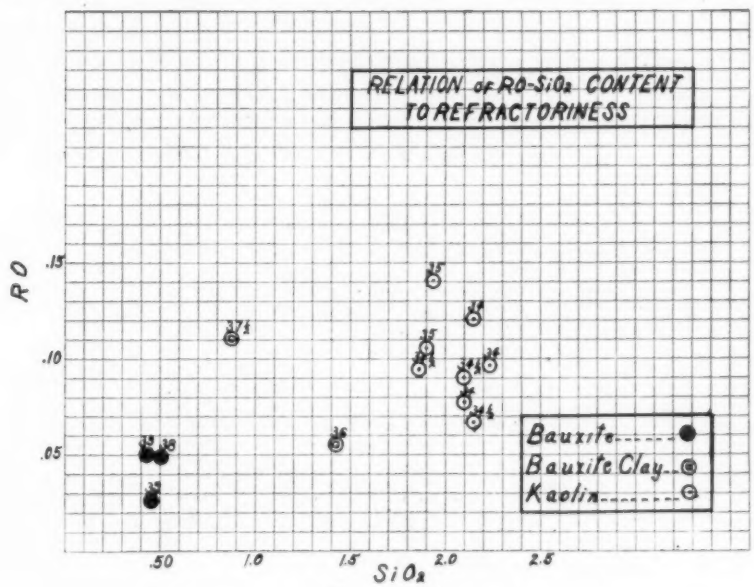

FIG. 1.

is comparatively expensive. Often it is necessary to move a ton of inferior clay to get a ton of number one clay. The clay cost delivered at the plant may vary from one to two dollars per ton and in some cases it amounts to even more.

The kaolins and bauxites of Georgia were essentially surface deposits which have been covered with an overburden that varies from 3 to 40 feet in depth. Several deposits of substantial thickness are covered with comparatively thin overburdens. One deposit in particular is 28 to 40 feet in thickness. It is covered with an overburden that ranges from one foot in thickness along a ravine, up to 14 feet and will average about 8

TABLE I

CHEMICAL ANALYSES

Clay no.	G-1	G-3	G-5	G-7	G-10	G-11	G-12	G-13	G-14	G-15	G-19	G-20
Moisture 105°C	2.05	1.15	.98	.99	.35	.52	.89	.57	.46	.74	.60	.53
L.O.I.	12.67	13.33	12.73	13.42	24.07	14.13	25.89	21.97	25.41	13.79	13.23	17.17
SiO_2	45.61	46.56	45.78	43.82	16.09	42.59	14.08	24.80	14.42	43.25	46.56	35.95
Al_2O_3	36.15	35.51	37.01	38.26	55.48	38.04	55.34	47.99	56.23	39.45	36.57	43.32
Fe_2O_3	1.47	1.59	1.11	1.44	1.77	1.59	1.65	1.92	.96	.96	.99	1.35
TiO_2	.77	1.29	1.32	1.60	2.04	2.34	1.98	1.88	2.34	1.17	1.48	1.60
P_2O_5	.05	.05	.06	.05	.06	.08	.07	.04	.01	.04	.01	.06
CaO	.80	.39	.35	.17	.16	.88	.14	.95	.31	.24	.35	.14
MgO	.30	.25	.18	.10	.08	.12	.06	.21	.12	.11	.24	.11
K_2O	.43	.00	.75	.13	.00	.00	.04	.00	.00	.16	.00	.00
Na_2O	.00	.00	.03	.29	.00	.00	.06	.00	.00	.38	.00	.12
Sulphur	.02	.03	.06	.02	.02	.05	.05	.03	.06	.15	.01	.03
Cone	34	34	34½	35	38	35	39	37½	39	34½	34½	36

feet. Such a clay can be mined by stripping, and delivered to the plant at a cost of approximately 20 to 30 cents per ton.

Laboratory Tests

Of the above-mentioned 30 clays, 13 were tested for refractory purposes. The chemical analyses and deformation cone are given in Table I. In Fig. 1 are plotted the RO–Al_2O_3–SiO_2 ratios of the several clays. The iron is figured as FeO. TiO_2, P_2O_5, and S are omitted from the calculations shown in the diagram. These clays seem to owe their high refractoriness in most part to their low RO in general, and in particular to low alkali content. Besides the ordinary laboratory tests to determine the physical properties of these clays, full-sized fire brick were made and tested under load at furnace temperatures, spalling tests were run, and porosity determinations made.

The brick were made from a mixture of 60%, ten-mesh grog, calcined to cone 13, and 40% of the same raw material as bond. The brick were molded dry press and fired to cone 14. Data showing the physical characteristics of the clays are shown in Table II.

TABLE II

LABORATORY TESTS ON CLAYS GROUND TO 150-MESH

Sample number	Tempering water	Drying volume shrinkage	Drying linear shrinkage	Volume shrinkage cone 11	Linear shrinkage cone 11	Porosity[1]
G-1	41.06	24.83	7.70	40.05	15.68	29.20
G-3	35.76	17.05	5.40	43.41	17.29	40.70
G-5	38.50	22.68	7.10	38.01	14.74	22.82
G-7	35.20	18.71	5.90	41.88	16.55	36.20
G-10	28.60	11.03	3.50	44.77	17.95	27.77
G-11	39.66	20.38	6.40	43.09	17.13	24.30
G-12	29.68	14.49	4.60	47.10	19.12	29.56
G-13	32.80	7.53	2.50	45.15	18.14	27.05
G-14	33.83	12.90	4.10	47.87	19.52	19.46
G-15	38.73	15.83	5.00	37.32	14.42	25.72
G-19	42.40	13.34	4.30	52.17	21.79	55.10
G-20	30.13	11.32	3.70	44.86	18.00	15.93
G-23	38.10	26.66	8.10	32.09	12.09	15.03

Note: The above figures represent per cent figured on basis of dry clay and test pieces.

The physical characteristics of the brick, made from the several clays and bauxites and burned to cone 14 are shown in Table III.

A second lot of brick was made from bauxites G-10 to 14, inclusive, and tested for spalling and load capacity at furnace temperatures. These

[1] All porosity determinations were made in the air expansion volumeter, and are, therefore, slightly higher than porosities determined by the saturation method.

brick were made dry press from a mixture of 70% of the bauxite calcined to cone 14 and bonded with 30% of kaolin G-3 and the brick fired to cone 16. Results of the tests are shown in Table IV.

TABLE III

TESTS ON DRY PRESS BRICK

Sample no.	Deformation temperature (cone)	Porosity cone 14 (per cent)	Spalling loss (per cent)	Load tests (lbs. per square inch)
G-1	34	28.28	0.50	1830 lbs. without failure, 1330°C
G-3	34	28.78	0.00	1830 lbs. without failure, 1330°C
G-5	34½	33.55	0.17	50 lbs. without failure, 1420°C
G-7	35	27.79	.34	50 lbs. without failure, 1420°C
G-10	38	44.20	13.15	Not tested
G-11	35	39.32	16.95	Not tested
G-12	38+	42.65	22.40	Not tested
G-13	38	43.75	25.15	Not tested
G-14	39+	42.81	18.30	Not tested
G-15	34+	35.83	0.58	50 pounds without failure, 1420°C
G-19	34+	41.45	14.15	50 pounds without failure, 1420°C
G-20	35+	36.87	0.52	50 pounds without failure, 1420°C
G-23	33	35.48	9.25	50 pounds without failure, 1420°C

Samples G-10 to G-14 inclusive are bauxites. The brick made from these materials were friable and of a very weak structure and should be burned considerably above cone 14 in order to give them the mechanical strength to withstand spalling and load.

They are comparatively low in plasticity, and hence do not mold as readily as a kaolin bonded brick.

TABLE IV

Sample no.	Porosity (per cent)	Spalling loss (per cent)	Load test (1350°C)
G-10	36.80	5.62	Failed at 691 lbs. per sq. in.
G-11	16.05	..	Cracked in burning. Not tested
G-12	31.60	0.39	Failed at 847 lbs. per sq. in.
G-13	35.40	1.68	Failed at 870 lbs. per sq. in.
G-14	39.20	5.14	Failed at 640 lbs. per sq. in.

Even though bonded with kaolin and fired to cone 16, these brick were not burned hard enough to give them best strength and lowest spalling loss. Their appearance indicated that they would have been improved if burned at cone 18. However, G-12 and G-13 gave very good results in both the spalling and load tests.

Large Scale Tests on G-3

Kaolin G-3 is typical of a number of deposits of the Georgia Coastal Plain. This kaolin was, therefore, selected for the large scale tests. A carload was shipped to a fire brick plant and made into standard sized fire brick by the slush mold-repress process in the regular manner. These

brick were made from 60% of the clay calcined (in "dobies") to cone 14 and 40% of the raw clay as bond. The calcined and raw clays were ground together and tempered without screening, according to the regular plant practice. The brick were burned in the kiln in three benches to cones 10, 11, and 14. The total linear shrinkage of the cone 14 brick calculated on the burned length as basis was five and sixty-seven hundredths per cent. Half of this was dry shrinkage and half burning shrinkage.

The average weight of several standard sized kaolin fire brick was $6^1/_2$ pounds, as compared to seven pounds average weight of standard sized fire-clay fire brick. The difference of a half pound in weight per brick, therefore, means a saving of 500 pounds per thousand brick, an item which comparatively reduces freight cost materially. Every ton saved in the refractories for boiler settings in naval craft and ocean-going liners means a ton increase in displacement for ammunition, fuel, or freight.

Spalling and load tests at furnace temperatures were made on brick burned at cone 14 in comparison with a well-known Pennsylvania flint fire-clay brick of excellent qualities. The results of the tests were as follows:

Deformation temperature	(cone)	Porosity (per cent)	Spalling (per cent)	Load at 1350°C
G-3 brick,	34	34.0	2.22	Withstood 733 lbs. per sq. in. without failing. (Max. capacity of machine.)
Penna. brick,	31	20.8	1.52	Failed at 485 lbs. per square inch.

Service Tests

Malleable Iron Furnace.—A bung of 40 G-3 brick burned at cone 10 was tested in a malleable iron furnace of the Ohio Malleable Iron Company at Columbus, Ohio. The bung was tested in the most severe position in the furnace which is directly above the bridge wall where the fire gases leave the furnace and start their passage over the hearth and burden of metal to be melted. When operating at one heat per day, the furnace is heated and cooled slowly so that the conditions are not severe on the brick, but when operated at two heats per day, the heating and cooling are done rapidly, thus imposing more severe treatment upon the brick, and their life is thereby materially shortened.

Two brands of brick, one from Pennsylvania and one from Missouri, had been found by the Company to give maximum service. When the furnace was operated at one heat per day, these brick would last for eighteen to nineteen heats, but when the furnace was operated at two heats per day their life averaged only 11 heats.

The G-3 brick withstood 11 heats with the furnace operating at two heats per day. The brick showed no evidence of failure through corrosion, as was the case in the two commercial brands, but they failed through

spalling. The brick used showed an average porosity of 32.8% and a spalling loss of 7.98% as compared to a porosity of 32% and a spalling loss of 2.22% for the brick burned to cone 14. Even though these brick were not burned hard enough to withstand spalling, they gave as good service as the best commercial bung brick the plant has been able to obtain. A bung of 40 brick burned to cone 14 was later tested and lasted through 11 heats. The brick were in much better condition at the end of the test than were the cone 10 brick. The condition of the cone 14 brick, as compared to the Pennsylvania brick at the end of the test, is shown in Fig. 2.

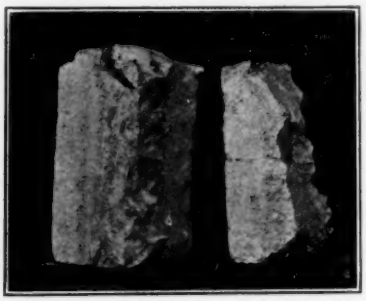

FIG. 2.—Brick removed from bung at end of eleven heats; (left)—kaolin, (right)—fire clay.

Electric Furnace Doors.—Tests were made on G-3 fire brick placed in a door of a three-ton Ludlum electric steel melting furnace of the Bonney Floyd Company of Columbus, Ohio. After a long series of experiments on different types and brands of brick, the plant has adopted a silica brick as one giving maximum service.

The furnace is provided with two doors, one at each end. One door was lined with silica brick and the other with G-3 kaolin brick. Brick in these doors, in addition to receiving a high temperature, must withstand the cutting action of slag and metal which is continually thrown against them by the furnace arc.

FIG. 3.—Kaolin brick removed from electric furnace door at end of 62nd heat.

The silica brick failed after 48 heats as compared to 62 heats served by the G-3 fire brick, an increase of 14 heats or almost 30%. When the two doors were removed, their appearance was substantially the same. Records of tests at the plant show that fire-clay fire brick fail on the average after about 35 heats.

The kaolin brick showed no tendency to spall. Failure was finally due to the fact that the door was corroded at the bottom until too thin for safety.

There was almost no penetration of the slag, as is clearly shown in Fig. 3, which is a photograph of the brick removed from the badly corroded portion of the door.

Electric Furnace Roof.—The third span from the door in the silica brick crown of the Ludlum electric furnace was laid up with the kaolin brick in

order to compare their service as against that of the silica brick. Practice at this plant was to operate a roof for two weeks and to put in a new one over the week end. At the end of the two weeks the brick would often be good enough to last much longer, but since only one furnace was in operation, no chances were taken of having a roof fail during the week. As the roof in which the test was being run was in good shape at the end of two weeks, it was decided to use it for another week in order to make the test more severe.

The entire crown was in fairly good shape at the end of the third week. The kaolin brick were in as good shape as the silica brick on either side

FIG. 4*a*.—Silica brick removed from roof of electric furnace after three weeks, service.

FIG. 4*b*.—Kaolin brick removed from roof of electric furnace after three weeks' service.

of them. In Figs. 4*a* and 4*b* are shown brick removed from the crown at the end of the test. The silica and kaolin brick were side by side in the setting.

It will be noted on the portion broken from brick that there has been less penetration in the case of the kaolin than in the silica.

Ladle Lining.—At the plant of the Bonney-Floyd Company, tests are also in progress to determine the behavior of these brick as ladle linings. Fifteen of the brick were placed in the bottom of an open-hearthed ladle, where difficulty is experienced in getting ordinary fire brick to "hold up" due to the fact that they must withstand heating to the temperature of molten steel and then water cooling between heats. Under this treatment ordinary fire brick fail after two or three weeks through spalling and disintegration. The 15 G-3 fire brick were placed in service January 19, and have shown no signs of spalling or crumbling up to the present time (April 7). They have, therefore, been in service over 11 weeks without showing signs of failing.

Boiler Setting.—Trouble was being experienced in securing proper refractories for the side walls in a stoker-fired fire box at the heating plant at Ohio State University.

Carborundum brick are used along the fuel bed and are giving good service, but due to local heating produced by the stoker, the fire-clay brick immediately above the fuel bed are dripping badly. One hundred of the kaolin brick burned to cone 14, which were placed in a side wall immediately over the carborundum, are standing up well while a Kentucky fire brick, recommended for the service by a local dealer, has been cut away badly on both sides of the kaolin brick. The test has not been in progress long enough to foresee the final outcome, but it is evident that the kaolin fire brick will outlast the fire-clay fire brick by a considerable margin.

Oil-Fired Furnaces

Two hundred of the G-3 brick burned to cone 14 were laid up in a checker baffle in the combustion chamber of an oil fired Wickes vertical tube boiler at a Gary, Indiana plant. The flame was supposed to impinge on a target before coming in contact with the baffle, although at times the flame licked the wall. A temperature of from 2800° to 3000°F was said to obtain at the baffle. The best grades of fire brick had a life of from 48 to 96 hours, depending upon the length of the oil flame. The kaolin brick held up fairly well for about eight days, although they began to pull away from the walls after 48 hours, evidently due to shrinkage. Highly aluminous brick held up somewhat better than the kaolin brick under the same circumstances. The failure in all cases was due to the intense heat and the corrosive action of the oil flame.

The test was not very satisfactory as the failure was so gradual that no end point could be determined. The life of the different refractories tried out varied enormously among themselves, depending on whether the flames actually impinged upon the brick being tested.

Conclusions

The Georgia sedimentary kaolins, bauxitic clays, and bauxites tested show deformation values from cones 34 to above cone 39; showed superior load carrying capacity and good resistance to spalling.

Enough work has been done to demonstrate the fact that these refractory materials can be made into fire brick in a practical way both by the dry press and slush mold-repress processes.

Furnace tests under actual working conditions have shown that the service rendered by fire brick made from Georgia sedimentary kaolins were at least equal to and in the majority of cases superior to fire clay and silica fire brick.

Inasmuch as the high-grade accessible fire clays are waning, the average quality of the fire brick decreasing, and the demand for better fire brick increasing, it would appear that the future of the fire brick industry lies in the utilization of the sedimentary kaolins, bauxitic clays, and bauxites of the coastal plain. Vast areas are underlaid with deposits of such substantial thickness that there is enough high-grade material to meet the needs of the refractory industry for years to come.

GLASS WOOL HEAT INSULATION IN EUROPE

By A. D. Saborsky

Modern heat insulation is a comparatively young art. People who were apt to notice the tiniest leak of live steam, or who would worry about their water bills, when a faucet dripped, felt perfectly at ease and ignorant about the loss of heat from poorly insulated pipes. We all know that this attitude does not prevail today, and the steady growth of our insulation manufacturing concerns in the past decades is ample proof for it.

When we speak of high grade heat insulation here in U. S. A. we mostly involve the so-called asbestos insulations, of which asbestos forms only a small part (15% and less in the best insulations), and merely acts as a fibrous binder for the real insulating material, which is primarily carbonate of magnesia, a very friable and crumbling material. The more asbestos these insulations contain, the heavier they become, and the poorer in insulating value. Of other heat insulations used I may mention mineral wool, slag, some siliceous earth (Kieselguhr), clay, paper preparations, cork, and so on.

The demands made upon an ideal insulating material are so exacting and manifold that the heat insulating materials on the market today are only able to comply with a selected few of these specifications. Glass wool however has proved in practice as well as laboratory tests the closest to being an ideal heat insulator.

The following are the characteristics for an ideal heat insulation material:

1. Low conductivity
2. Low specific heat
3. Light weight
4. Withstand vibration
5. Withstand destruction by blows
6. Flexibility to
    - (*a*) Conform to most any shape
    - (*b*) Follow a surface, expanding under heat
    - (*c*) Withstand rough handling without damage
7. Withstand alternate heating and cooling
8. Withstand alternate wetting and drying
9. Easy, clean installation, possible by unskilled labor
10. Installation possible without stopping production
11. Contain a maximum of dead air cells
12. Be non-hygroscopic
13. Withstand extreme temperatures
14. Be proof against damage by steam, water, chemicals, air, rodents, etc.
15. Be comparatively cheap in cost and installation.

The first successful tests with glass wool for insulation purposes were made as early as 1904 in Bohemia (the present Czecho-Slovakia). The high qualities of glass wool as an insulating material were recognized right then, and even though the price, based on manufacturing methods then

in vogue, was almost prohibitive, it sold on its sheer quality for special insulations. Before the advent of the War there were already hundreds of chemical, textile, rubber, paper factories, etc., as well as some power stations and steam ships using and specifying this material in Central and Eastern Europe. The list includes firms as the Okulowska Paper Company of Moscow, which wrote September, 1913 "....We are using glass wool on superheated steam of 680°F, and also on saturated steam lines, as well as on our boilers and vats, and it supersedes all other insulations we used...." In one of their tests with an 8-inch glass wool insulated pipe, carrying superheated steam of 630°F and with a temperature of the surrounding air of 104°F, the drop in temperature per yard of pipe length was only .46°F. The surface temperature of the insulation remained only 9°F higher than the surrounding air. In December, 1910, the Cautchouc Company of Riga, Russia confirm that they were very satisfied with the glass wool insulation on their Diesel engine exhaust pipes, stating that ".....with the motors under full load, the temperature difference between the surface and the surrounding air was only 35°C, and as you guaranteed 50°C, this guarantee has been well met. The thickness of our insulation is 70 mm. (about $2^3/_4$ inches)....." The Textile Company of the same town asserts in the same year, that ".....our glass wool insulation, which is steadily exposed to acid and water vapors is still in perfect condition....." Of the German concerns who installed this material before the War, I mention as some of the largest ones Friedrich Bayer & Company, who writes March, 1919, that ".....the insulations installed in 1910 are still in perfect order.....;" the large locomotive works of Orenstein & Koppel, the elevated Railway of Hamburg, the Royal Canning Factories of Spandau, the Wilhelmina Mine and many others.

FIG. 1.—After 12 years' service.

In January, 1921, some steam hammers of the firm of Orenstein & Koppel, whose pipes had been insulated with glass wool way back in August, 1909, were dismantled. Their insulation had been in continuous use for almost 12 years, carrying steam of 470 to 550°F, being exposed all the time to the shocks and vibration, coincident with steam hammer practice, and when this insulation was removed the glass wool was found to have retained all its good insulation qualities and resiliency. Samples of this wool were labeled and attested by notary public (Fig. 1).

In 1914 the War started, and with it an immediate and entire lack of asbestos importations for Central Europe set in, aggravated by a still greater necessity for the preservation of fuel. Glass wool, whose excellent

insulation qualities were already recognized, was then called upon irrespective of cost. A firm of ship chandlers in Hamburg, who up to that time had carried a line of asbestos insulations, started to supply the rapidly growing demand for glass wool, at first employing the crude manufacturing methods then available. Gradually as they found themselves unable to comply with the steadily increasing demand, different methods to improve the manufacture were repeatedly tried, put into production and abandoned again, when better ways were discovered. In this way they covered the ground from the semi-manual making of glass wool from glass rods to present day automatic production directly from a vat of molten glass, with scrap glass as the raw material.

FIG 2.—Locomotive wire net mattress.

They finally succeeded in perfecting their machinery to such an extent, that today glass wool insulation is being sold not merely on account of its superiority, but is being offered at competitive prices.

Today, only four years since industries started to readjust themselves to peace conditions, there are thousands of factories and power stations specifying and buying glass insulation. Over 10,000 German government locomotives are already carrying glass wool insulation, which is especially desirable for this service, and also countries as Spain, Holland, Denmark, Roumania, Bulgaria, Hungary, Russia, Argentine, Brazil, and others are using it for the same purpose. (Figs. 2 and 3.) Due to its lightness and high qualities this material is absolutely without peer for insulation on shipboard, and I may mention as the latest ships thus equipped the "Resolute" and "Reliance" of the U. S. Line, the "Majestic," the latest and largest (58,000 T.), White Star Liner, the "Hansa" of the Hamburg-American Line, the "Noordam" of the Holland-American Line, four ships of the German-Australian Line, at least six steamers of the South American Line, and many others. (Fig. 4.)

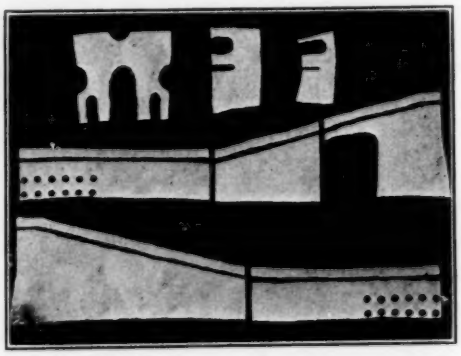

FIG. 3.—Fire box wire net mattresses.

Of the largest manufacturing enterprises using glass wool today I select the following names.

Among Power Stations:

"Continental Rubber," Hannover
Reichardt Cocoa, Wandsbeck
Central Electric Station, Hamburg, etc.

Among Chemical Factories:
German American Oil Co., Hamburg
Dessauer Sugar Co., Dessau
Wolfen Film Co., Bitterfeld, etc.

Among Shipyards:
Blohm & Voss, Hamburg
"Vulcan," Hamburg
"Weser," Bremen
and every other large German shipyard

On Steam Hammers
Maschinen Werkstätte Augsburg
Bismarkhuette, Silesia
Vulcan Werke, Hamburg; etc.

On Locomotives and Railroads:
Friedrich Krupp, Essen
Borsig, Berlin
Schwartzkopf, Berlin
and practically all other locomotive builders

In Mining:
Laurahuette, Silesia
Koenigshuette
Bismarkhuette, etc.

Many laboratory tests were made by independent and unimpeachable authorities. Professor Oscar Knoblauch of the University of Munich, an international authority on thermodynamics, established the heat conductivity per cubic meter of glass wool, per one degree C surface difference per hour, as follows:

At 0°C	0.030 Calories
At 50°C	0.037 Calories
At 100°C	0.043 Calories
At 200°C	0.056 Calories
At 300°C	0.070 Calories

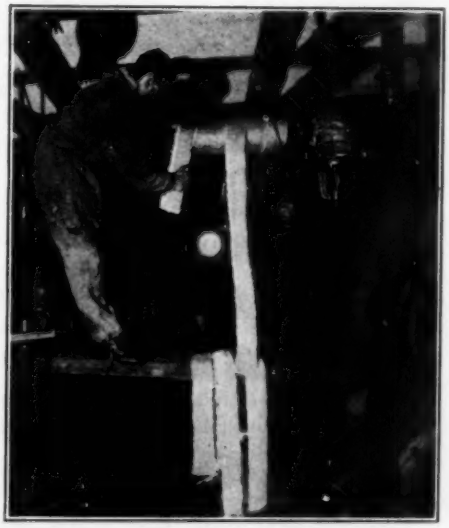

FIG. 4.—Band insulation on shipboard.

Above low figures have not been attained by any other heat insulation on the market, and have been proved repeatedly by different sources and in different countries, as by Professor Mitchel of the University of Moscow, by the Technical University of Prague, and a number of other high standing institutions in Europe. These figures have also been confirmed by a number of private enterprises having their own laboratories, and using glass wool insulation.

The factor of heat conductivity is the only scientific means for just comparisons and a table of curves displaying the conductivity of different materials shows glass wool insulation as the lowest curve. (Fig. 5.)

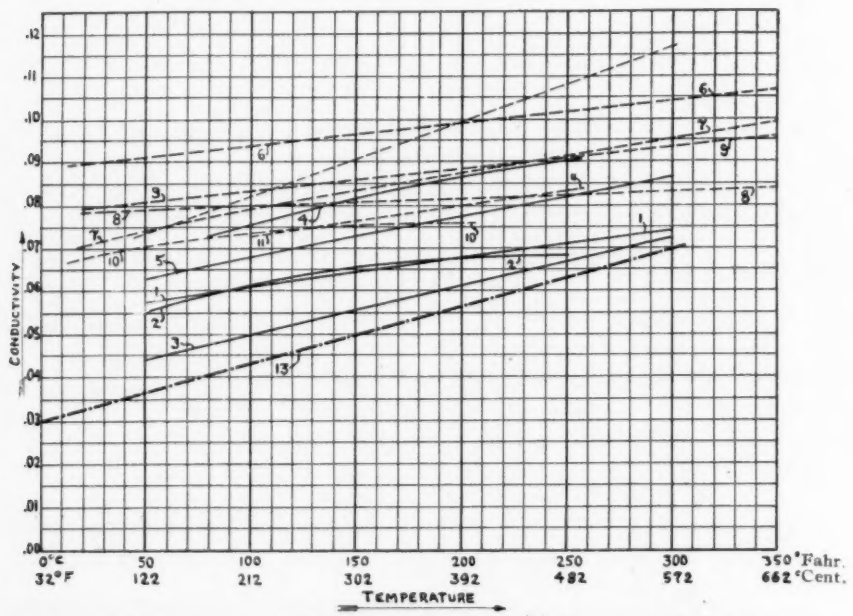

FIG. 5.—Conductivity of different materials [in calories per cubic meter per Centigrade-hour]. Curves 1 to 12 from "Forschungshefte" V.D.I. issue 228, p. 46; Curve 13 as per tests of the University of Munich [Prof. Dr. O. Knoblauch].

		Lbs./ cu. ft.
1.	Asbestos-magnesia—loose mixture,	26.3
2.	Asbestos-magnesia—loose mixture,	22.2
3.	Asbestos-magnesia—loose mixture,	15.3
4.	Asbestos-magnesia—cast slabs,	24.0
5.	Asbestos-magnesia—cast slabs,	17.7
6.	Asbestos-kieselguhr—loose mixture,	41.7
7.	Asbestos-kieselguhr—loose mixture,	39.0
8.	Asbestos-kieselguhr—loose mixture,	38.0
9.	Asbestos-kieselguhr—loose mixture,	34.3
10.	Asbestos-kieselguhr-cork—loose mixture,	20.9
11.	Asbestos-kieselguhr-cork—loose mixture,	20.0
12.	Kieselguhr—baked slab,	20.4
13.	Glass wool—band form,	13.7

Speaking practically and taking the average for the different temperatures, glass wool insulation of about 20% less thickness will replace the best grade asbestos insulations; and glass wool of about one-half the thickness will replace mineral wool. The above figures apply to plane surfaces, in insulating pipes or curved surfaces. However, this difference in thick-

ness becomes wider and wider as the diameter decreases. Materials whose conductivities stand 1 to 2 for instance, and where double the thickness of the poorer would replace a single thickness of the better insulation on plane surfaces, would differ as much as 1 to 4, even 1 to 6 and more in thickness, to result in the same amount of insulation on a curved or round surface. The above example of 1 to 6 would apply to the extreme case of a $^3/_4$-inch pipe, giving equal insulation with either $1^5/_8$-inch glass wool insulation or 10 inches insulation of the material having a heat conductivity twice as big. The cause for this steadily growing advantage of the higher grade insulating material with the decreasing size of the pipes used, is due to the simple fact, that with the necessary added thickness for the poorer material, the outer circumference, or surface exposed to the surrounding air, also increases, resulting in an additional loss of heat, and requiring again more insulation. As insulation is used more on pipes than anywhere else, the value of a high grade insulating material is obvious.

Next of importance is the lightness of glass wool, whose weight per square foot of 1 inch thickness is only 1.14 lbs., as compared with 1.47 lbs. and more for the best asbestos-magnesia insulations.[1] What this light weight means, and especially for carriers, mainly ships, may be appreciated by considering that ships of the "Sebastopol" class (Russian battleship of the 1914 period), for which I happen to have the figures at hand, could save as much as 348,450 kilograms, or about 380 tons in weight by using glass wool insulation. These 380 tons, corresponding to the combined weight of about 4500 people, mean for this ship of 460 feet length, about 4 inches less draft, which again by reducing the resistance in the water results in a saving of coal.

Glass wool's mechanical strength and flexibility as compared with other insulating materials should not require scientific tests for anybody who ever handled or saw the materials. However it may be stated that 85% magnesia, asbestos claims a crushing strength of 100 lbs. per cubic inch,[2] which means 100 lbs. gradually applied and without shock, and though I have to admit that no laboratory figures are available on the crushing strength of glass wool, it may be comfortably tested by any heavyweight by simply stepping or jumping on it. This test will break a few of the longer fibers into shorter pieces, without impairing the insulating qualities.

Heat is being transmitted in three ways: by conduction, convection and radiation. Glass wool is the only insulator to meet all three. The first by its low conductivity, the second by the millions of dead air cells, preventing circulation, and the third by the reflection of the heat waves by each one of the silvery, smooth and shiny threads of glass.

[1] Johns Manville Catalog.

[2] E. R. Weidlein, *Chem. & Metal Eng.*, vol. 7.

As one cubic foot of glass wool weighs about 13.8 lbs. and as the average glass may weigh about 156 lbs. per cubic foot, about 90% of a given volume of glass wool is taken up by dead air cells.

Glass has been used long enough in chemical industries so that its favorable behavior in this respect does not require further comment. As we also know, it is resistant to moisture and air, and is non-hygroscopic.

Surprising, however, is the resistance of glass wool insulation to temperatures far over the melting temperature of glass, and where other high grade insulating materials deteriorate very quickly. Glass wool when so exposed will bake and even melt for about $^1/_8$ inch and sometimes $^1/_4$ inch right next to the overheated surface, and where it is in direct contact with the red hot iron. The fibers, however, behind this baked wall will remain unaffected and continue to give perfect and permanent insulation. This baking may begin at temperatures as low as 1200° to 1500°F, depending on the hardness of the glass used. A baking of this kind takes place for instance on the exhaust pipes of heavy oil engines, where this material has proved to be the only suitable one. These exhaust pipes are continuously red hot and burn out periodically. Whenever such a pipe had to be replaced, the glass wool was found to be in perfect condition and pliable, with the exception of the thin baked layer right next to the pipe. How confident the manufacturers of this glass insulation are in this resistance to high temperatures is shown by the fact that they are now recommending it for the outside insulation of industrial furnaces for the melting of iron and metal.

The early methods of manufacturing glass wool were very crude and simple. The workman melted the tip of a glass rod over a gas flame, seized with another glass rod the forming drop, and threw it, with a quick twist of his hand, over a rotating drum, foot-operated by himself.

The first machines introduced, and those available when the War started, held a number of glass rods clamped in a horizontal position, feeding them gradually into a gas flame, at the same time turning them slowly, to provide for an even heating. (Fig. 6.) The work of the spinner merely consisted of drawing the forming drops over to the continuously revolving drum, by means of a glass rod. He had to renew the tearing threads in the same manner, and also stop the machine to renew rods that had been consumed, except for the short stub remaining inside the clamp.

The biggest advance in spinning was made by the very obvious and long delayed improvement of placing the revolving drum underneath the falling glass drops, thus doing away with the labor of continuously conveying and fastening glass drops to the drum. (Fig. 7.) This simple improvement proved to be so basic in the art, that very strong patents were obtained on this feature. The drops now fell automatically, by gravity on to the drum, drawing the glass threads after them, and also renewed

the threads, when any of them broke. The drops themselves were thrown off by the centrifugal force of the turning drum, which retained only the pure and light wool. All the spinner had to do was to renew the glass rods, when consumed, and regulate the flames. One spinner was now able to watch three or four times the number of threads as before, with the drum ahead of him.

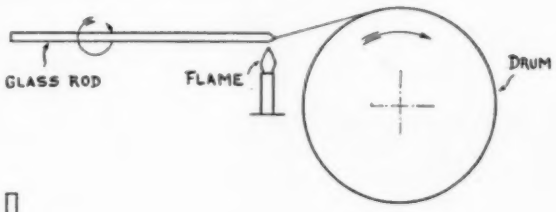

FIG. 6

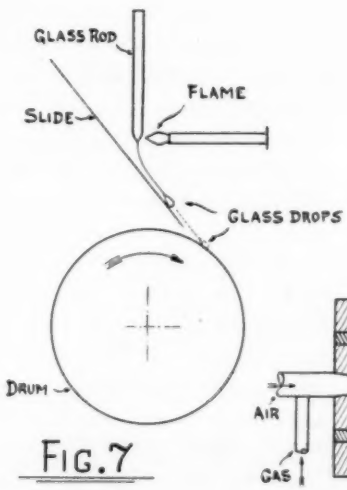

FIG. 7

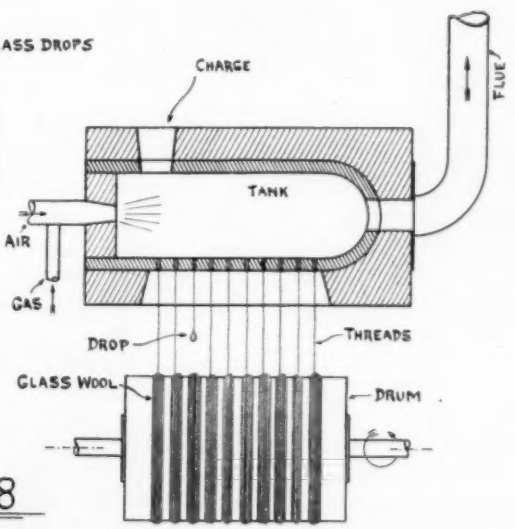

FIG. 8

As the cost of thin glass rods in Europe in pre-war times was about 7 cents per lb. whereas scrap glass had a market price of about $1^1/_2$ c., it was attempted very early to make glass wool directly from the molten glass, without the necessity to produce or buy glass rods first. Many methods were tried and abandoned, until at last the present way of using vats, containing the molten scrap glass, and provided with small openings at the bottom end was successful. From these openings the glass drops emerge, falling on to the drum below, and drawing the threads after them. (Fig. 8.)

Sometimes these openings are separately heated by an electric coil or gas flame, and sometimes air pressure is put above the molten mass. There are still smaller improvements possible no doubt, but these machines are working now and producing continuously, and the making of glass wool from rods has been abandoned entirely about a year. The factories, though they can not be called large establishments according to our standards, are now producing an average of more than 8 lbs. of wool per employee-hour, mostly girl labor being employed.

When one drum is loaded with glass wool, it is stopped and the wool cut off and removed. The product is then carded and loosened up, a very simple process, but still performed by hand in a country where the necessity of economizing with labor has not quite reached our standards. (Fig. 9.)

FIG. 9.—"Carding."

Quite manifold are the ways in which glass wool is applied as insulation. The most commonly used form is in the shape of bands about $^3/_8$ inch to $^1/_2$ inch in thickness and a width of from two to ten inches. This insulation weighs about three to four pounds per square yard. The loose and carded glass wool is put upon a table, mostly upon a sub-foundation of paper, burlap, or wire mesh, and run through sewing machines, which sew rows of stitches about $1^1/_2$ inches to 2 inches apart into the wool sheet. The glass mattress is then run through cutting machines, cutting the bands to the desired width. In applying this insulation, these bands are simply wound spirally around the pipes in one or more layers. (Fig. 4.) The insulation may be finished off on the outside by bandaging and painting in customary manner, if so desired. When larger surfaces and not pipes are to be insulated by this method, the mattresses are not cut into bands, but trimmed to the size required. (Fig. 10.)

Larger pipe lines and objects are often insulated by first surrounding them with coarse wire-mesh, distant from the object, to represent the outline of the finished insulation. The glass wool is then simply stuffed in between the wire mesh and the body to be insulated. (Fig. 11.)

The highest grade insulation, and the one used exclusively on locomotives, boilers and other objects, where the insulation has to be removed at intervals to make inspection and repairs on the machinery or boilers, is made in the following way. From a drawing or sketch two templates are cut out of wire mesh of the weave of narrow chicken wire. Next these two templates reach an operator, to whom also a certain amount of glass wool, figured in so many pounds to the square inch, is allotted. In the above process about 3 to $5^1/_2$ lbs. per square yard are figured, depending on the quality of insulation desired. The girl distributes the glass wool received evenly over one of the templates, covers the whole with the other template, and crimps the edges. On large surfaces she may crimp a few wire staples through the center. The mattress is now ready to be fastened to the object to be insulated, can be removed whenever required, and will stand all kinds of rough usage. (Figs. 2 and 3.)

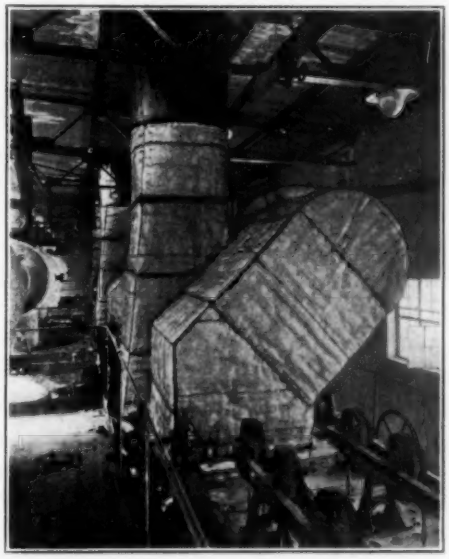

FIG. 10.—Sewed mattresses.

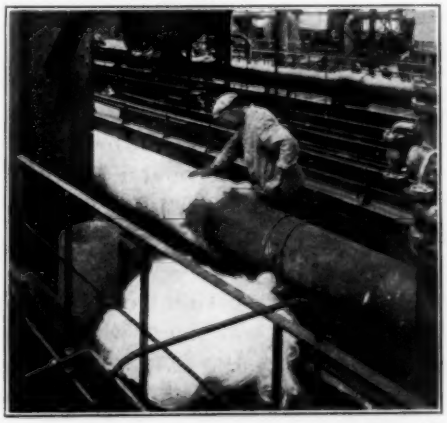

FIG. 11.—"Stuffing" glass wool.

Glass wool is now being manufactured in considerable quantities and economically. The German factories in Hamburg, which have enlarged to several times their original size, have been working on three 8-hour shifts since 1918. A large new factory for the production of glass wool is under construction in Dresden, Saxony, where every furnace will feed three vats of two hundred openings each. It is estimated from present production figures that about 6500 lbs. of wool would be produced in 24 hours working time. The help required would be two spinners, one melter and one helper per furnace, which would result in an output of almost 70 lbs. per man per hour.

It would be preposterous for me as a layman in glass generally, to attempt estimating the American costs for the manufacture of glass wool. The more so as the German costs, with the constant rise and fall of the mark, and the daily changing wages, can hardly be used as a base. The fact is that the German manufacturers themselves can not establish their present costs, nor can it be established for them by any accounting method in captivity. The amount of labor required to produce a pound of wool has been stated above. The fuel consumption is 32 cubic feet of artificial gas per one pound of glass wool. The wastage of material in the shape of drops, etc., amounts to about 10%, which waste is remelted in the next load or in a smaller furnace. The manufacturers of glass wool, setting their material as the most important item at 100 units, figure their labor at 40 units, and their overhead again at 40 units of their total cost. Translated into our usage this means 100% overhead, based on labor. Faced by the impossibility of establishing his exact cost, the German manufacturer plays safe by fixing his selling price in foreign exchange, preferably *dollars*, and based on this dollar price makes his quotations in marks, according to the exchange value on the day of sale, or still better, the day of delivery. Glass wool insulation is selling for 12 cents per lb. in competition with the highest grade imported insulations. From what I have seen and heard I would reservedly place the manufacturing cost today at about $2^1/_2$ to $3^1/_2$ cents per pound.

Several patents were obtained during the development of the manifold processes and machines. All thinkable possibilities were tried, out of which the present machines finally crystallized. This process of producing glass wool directly from a molten mass of glass is new, and has been well protected in all civilized countries. The number of the American patent covering this feature is 1,427,014.

European glass manufacture of the type produced by machinery has never been able to gain a strong foothold in our country. As far as glass wool is concerned, the German manufacturers realize that introducing a new line like theirs into the vast field of heat insulation could not be done in a small way in U. S. A., and establishing branches, advertising, and paying for these and other incidentals of pioneering in foreign currency, constitutes an utter impossibility for them.

Born under the pressure of the past War, glass wool heat insulation is one of the very few inventions and substitutes of war times, which have proved valuable, and therefore have survived peace. Now that glass wool is available in quantities and cheaply, new fields besides insulation will probably be opened to this product as the years go by. But as far as insulation is concerned, there is no doubt to my mind, from what I have seen, heard and investigated as an engineer, that glass wool is the coming heat insulation, and coming fast.

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COPPER REDS FOR THE AMATEUR

By Paul E. Cox

ABSTRACT

A brief review of the history of the production of such wares is given. Methods are described that can be used by the person having china painter's kiln. This paper is presented to encourage the amateur to make use of simple equipment for the production of decorated wares in which a satisfactory ceramic red can be produced.

Introduction

Joseph F. Meyer, Alsatian Frenchman, son of a French peasant potter, for almost thirty years with Newcomb Pottery, and a clever craftsman, had for his heritage the recipes and processes of his country. From the material thus at hand and from his reading of the literature of his native country he developed a simple process of making copper reds which for some years were a part of the offerings of Newcomb Pottery. The jury at the St. Louis Exposition awarded a gold medal to this self-taught French peasant. A process similar to Mr. Meyer's for copper red effects is here described.

Any book that deals with the lusters produced by the Italian and Spanish faience potters, or the Turkish or Persian wares will suggest the process. The technique is elementary in the extreme. Certainly the French authorities on ceramic processes describe the process very well, but the application to the modern amateur china painter's kiln has not been made.

The Materials Needed

The Glaze.—The glazes of most whitewares are too refractory to admit of copper red staining. It requires a soft or easily softened glaze such as is used in the manufacture of jardiniers and the numerous little bowls and vases that are so strongly refractive or reflective of light. These are usually inexpensive. Matt glazes will yield copper reds but they are not very often interesting. Many little Japanese bowls and vases likewise are suitable for work of this sort.

The Equipment and Supplies.—A china painter's kiln, or any kiln in which a good red heat can be developed, will serve the purpose very well. A glass slab, a glass muller, some brushes, a little kaolin or ball clay or any other kind of clay, perhaps a little fine white sand or better some finely ground calcined clay, and either copper carbonate or copper oxide and some pitch pine knots make up the list of needed supplies.

The Applying of the Copper

On the glass slab mix a paste of clay with water, using the muller to grind the paste smooth. Add the copper oxide or copper carbonate in such amount as satisfies the worker that some copper compound will be

all through the mixture. It is safe to say that 10% will more than suffice. When the mixture is well blended apply in a good thick coat and allow the treated pieces to dry well before putting them into the kiln. The thickness of the coat should be roughly about $^1/_{16}$ of an inch.

It will be found that such a mixture will crack like the mud drying in a puddle. This can be overcome by using calcined clay, flint, sand, or similar non-plastic material. However some accidental effects are had from the peeling away of the coating that are at times desirable, so that the experimenter must decide what is desirable according to the end in view. A very little raw clay will serve to make sticky a very large amount of non-plastic material and so the control is at hand by varying the amounts of clay and non-plastic.

Fire-clay shelves or slabs should be procured from the dealer that furnished the kiln, with which to set up a muffle or built-up chamber in the kiln, so that the tubes and kiln walls will not absorb copper oxide vapors and later give it off again on white porcelains. The cost of this muffle protection will not be great, it facilitates the setting; and in every way the need justifies the expense.

The Firing of the Kiln

It will be assumed that the wares are placed on fire-clay shelves and that the kiln is ready to fire. The firing is done exactly as it would be done for painted china, except that when large pieces are present, they will be thicker bodied than porcelain usually is, so that the precaution must be observed of heating up more slowly. The kiln should be brought to a good red. Since the composition of the glaze will be unknown, the exact temperature must be determined by experiment. This is judged from two considerations. The kiln must be hot enough to make volatile the copper and to soften slightly the glaze of the wares. It must not be hot enough to soften the glaze sufficiently to cause the clay vehicle to stick to the ware. Obviously this point must be determined by test, but a china painter will not find this hard to determine, for it is within the limits of temperatures common to that craft.

When the maximum temperature desired is reached this must be maintained for an hour at least while the copper oxide is vaporized and deposited in the glaze and then changed from the green state to the red. Of course, all three processes are going on at once.

While the temperature is being kept at this maximum, pine knots are added one or two at a time by opening the kiln door and placing the knots on the floor of the kiln in a place reserved for them. This requires quickness of movement on the part of the experimenter to conserve the kiln heat. A pair of asbestos mittens will be helpful and a pair of suitable tongs will of course be needed. The knots will break into flame at once

and with the kiln door quickly closed a black smoke will fill the muffle chamber. This black smoke in the muffle at the maximum temperature must be maintained for an hour or more. The kiln then should be allowed to cool but the smoky atmosphere in the muffle should be maintained until a decided lowering of temperature is observed, which can be judged by the comparative dullness of the red of the heated objects.

Joseph F. Meyer used a small hand bellows to force the billowing smoke clouds about in the ware chamber, and so make more even the reducing action.

It should be noted in passing that Mr. Meyer did not use the china painter's kiln but a kiln similar in idea in which he burned coal and which is the type of kiln used so largely in France as a decorator's oven.

The writer has found that if the piece of ware is enclosed in a reasonably tight and reasonably close fitting clay vessel, which has been coated with the copper bearing paste and the same treatment is given, the red is produced without the trouble of washing away the coating after the firing. That is, there is no paste applied to the piece of ware that is being treated. Results are not so interesting however.

The Treatment after Firing

When the kiln is opened the next day, if everything has gone well, it will be found that the clay coating can be scrubbed off with water, and that the glaze has taken a more or less regular transparent red, and in places a luster. If the reduction has progressed far enough it will be found that copper appears as a metallic film. The desirable result is of course to have the red in abundance.

Blistering of the Glaze

Clément Massier, working in France, has produced some pieces which museums and collectors value, in which the glaze is much blistered. This results from firing at a higher temperature, and also some glazes are prone to blister under the treatment. Those who develop their own glazes can overcome this blistering by developing a harder glaze, while those who have to depend on a purchased pottery can but hunt until they find that which will work well.

Conventional Designs in Copper Red

Massier likewise produced wares with the red placed where he wanted it. For example, he had designs with a conventional frog whose eye was a devilish red. If the paste is placed on the eye of the frog and at no other place that will be the only red place on the ware.

Use of Colored Glazes

It will be found that wares with blue in the glazes, and most colors other than green, will yield the most interesting results. However colorless glazes quite often give fine results.

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Correction

Wilson, R. E., and Hall F. P., "The Measurement of the Plasticity of Clay Slips," *Journal of the American Ceramic Society*, **5** [12], 920 (1922), Fig. 3: The ordinates should be divided by 100; *Ibid.*, 924, Fig. 5: $\frac{W}{C}$ = 12.0 for Bentonite, not $\frac{W}{C}$ = 1.20; *Ibid.*, 925, Fig. 6: $(H^+) = 10^{-7}$, not $(H^+) = 10^{-10}$.

CERAMIC ABSTRACTS

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Vol. 2 | May, 1923 | No. 5

Author Index[1] to Abstracts for May

Author	Number of abstract
Ackerman, A. S. E.	109
Adams, I. E.	37, 41
Allison, L. W.	140
Amsler, W. O.	45
Anon.	3, 4, 5, 6, 7, 8, 9, 10, 13, 17, 18, 24, 48, 49, 50, 51, 55, 56, 57, 59, 60, 62, 64, 75, 81, 83, 86, 87, 88, 91, 92, 93, 106, 111, 133, 134, 135, 136, 137, 138, 139, 141, 142, 143, 144, 145, 146, 160
Antonoff, G. N.	115
Asahara, G.	63
Atkinson, J. S.	149
Baillie, W. L.	20
Benedicks, C. and Sörberg, E.	2
Bied	12
Boswell, P. G. H.	71
Boudouard, O. and Lefranc, J.	107
Brenner, R. F.	31
Brumbaugh, J. D.	103
Burchartz, H.	58
Buttolph, L. J.	127
Capp, J. A.	79
Carter, A. S.	23
Charriou	105
Chatley, H.	104
Chéine, S. D.	1
Cole, G. A. J.	100
Cousen, A. and Turner, W. E. S.	29
Cox, S. F.	46
Cressy, E.	158
Currie, J.	27
Davidson, F.	80
Davis, A. C.	14
Demorest, D. J.	150
Desch, C. H.	126
Desgraz, A.	11
Discussion	26
Drever, H.	148
Durbin, P. C.	69
Eckel, E. C.	16
Edmonds, W. G.	33, 36
Ells, S. C.	89
Elworthy, R. T.	90
Fabre, J. H.	159
Fahrenwald, A. W.	117
Farmer, F. M.	76
Fleury, P.	122
Flood, L. W.	61
Ford, W. E.	101
Frydlender, J. H.	151
Gardner, J. H.	44
Goucher, F. S. and Ward, H.	125
Grocholl, K.	67
Grout, F. F.	95
Harkins, W. D. and Feldman, A.	121
Harris, J. E. and Schumacher, E. E.	42
Hart, E.	131
Heuer, R. P.	65
Holmes, W. H.	32
Huntley, F. S.	35
J. L.	119
Jackson, F. G. and Shaw, L. I.	113
Johannsen, A.	98
Kallauner, O. and Hruda, J.	110
Kenney, A. W.	78
Krak, J. B.	39
Kraus, C. A. and Darby, E. H.	47
Kreisinger, H. and Blizard, J.	152
Levy, L.	155
Liddell, D. M.	130
Lidstone, F. M.	116
Lohman, C. J., Jr.	112
Lovejoy, E.	53
Lowry, T. M.	108
Manchot, W.	123
Manly, J. J.	153
Marshall, A. E.	43
Mayers, W. S.	38, 40
Norris, W. F.	28
Pile, S. and Johnston, R.	128
Petts, E.	52
Rees, W. J.	30
Rideal, E. K.	120
Ries, H. and Bayley, W. S.	97
Rimbach, R.	147
Rishkevich, E.	68
Rohn, W.	74
Roth, E.	73
Sauvageon, V. M.	34
Scott, A.	118
Smalley, E. L.	84
Smith, W.	70
Sortwell, H. H.	72
Strickland, D. M.	156

[1] The abbreviation (*C. A.*) at the end of an abstract indicates that the abstract was secured from the Editor of *Chemical Abstracts* by coöperative agreement.

Author Index to Abstracts for May (*Continued*)

Author	Number of abstract
Thompson, J. G.	114
Turner, W. E. S.	19, 25
Turner, W. E. S. and Hodkins, F. W.	22
Van Dusen, M. S.	124
Vogt, J. H. L.	94
Waeser, B.	154
Wallace, A. M.	132
Washington, H. S.	96, 129
Watson, J.	15
Weed, J. M.	66
Wescott, H. P. and Diehl, J. C.	82
Wilson, G. V.	85
Winchell, N. H. and A. N.	99
Withey, W. H.	21
Wollaston, T. R.	157
Woodson, J. C.	77
Wyer, S. S.	102
Zakharoff, A. A.	54

Abrasives

1. The manufacture of aluminium in Russia. S. D. CHÉINE. *Communications travaux tech. sci. effectués Republique Russe*, **5**, 71–3(1921); *Rev. métal.*, **19**, 568–9 (Abs.) (1922).—B. J. Zbarsky has worked out a method for the com. sepn. of Fe salts from a soln. of $Al_2(SO_4)_3$, which allows of working kaolins by the so-called acid process for the production of Al. Kouznietsoff and E. J. Joukovsky treat a mixt. of Al ore, baryta (or $BaCO_3$) and Fe scrap in an elec. furnace, obtaining products such as ferro-Si and Ba aluminate (the latter in the form of a slag). The Ba aluminate is dissolved in water, and the Al is prepd. by one of the usual methods and the recovered Ba is re-used. This process is suitable for the Tikhvine bauxites, which contain large amts. of SiO_2 and of Fe and which could supply the whole Russian requirements of ferro-Si. A. P.-C. (*C. A.*)

2. Improvement of emery papers. CARL BENEDICKS AND ERIK SÖRBERG. *Z. Metallkunde*, **14**, 397–9(1922).—Ordinary fine-sized emery paper is fastened to a coarse book-binding paper under pressure so as to provide furrows which will care for the sepd. emery particles and prevent excessive scratching. Photomicrographs show steel samples polished with ordinary and improved paper. W. A. M. (*C. A.*)

Cement Lime and Plaster

3. Tentative methods of testing gypsum and gypsum products. ANON. *A. S. T. M. Tent. Stand.*, 307, **1922.**—Detailed chem. methods are given for the detn. of free and combined H_2O, CO_2, SiO_2, Fe_2O_3, Al_2O_3, CaO, MgO, SO_3, NaCl. Physical tests include detn. of fineness, consistency, H_2O carrying capacity, dry bulk, wet bulk, time of setting, tensile and compressive strength, and sand carrying capacity. E. N. BUNTING

4. Tentative definitions of terms relating to the gypsum industry. ANON. *A. S. T. M. Tent. Stand.*, 320, **1922.**—The following are defined: accelerator, aggregate, binder, cement, consistency, lath, mortar, plaster, plasticity, retarder, stucco, and wood fiber. E. N. B.

5. Tentative methods of making compression tests of concrete. ANON. *A. S. T. M. Tent. Stand.*, 299, **1922.**—Detailed instructions are given for this test. E. N. B.

6. Tentative specifications for gypsum. ANON. *A. S. T. M. Tent. Stand.*, 268, **1922.**—Includes: I. Materials and Standards. II. Sampling. III. Packing and Marking. IV. Inspection. E. N. B.

7. Tentative specifications and tests for compressive strength of Portland cement mortars. ANON. *A. S. T. M. Tent. Stand.*, 229, **1922.**—Compress. strength in lbs. per sq. in. should = 1200 after 7 and 2000 after 28 days. Test piece should be in form of cylinder 2″ diam. x 4″ length molded from non-corroding molds. Any calibrated testing machine may be used. Samples differing > 15% from av. should not be considered in detg. compress. strength. E. N. B.

8. Tentative specifications for concrete aggregate. ANON. *A. S. T. M. Tent. Stand.*, 259, **1922.**—Sieve tests, strength tests and color test are covered. E. N. B.

9. Tentative specifications for quicklime and hydrated lime for the manufacture of silica brick. ANON. *A. S. T. M. Tent. Stand.*, 257, **1922.**—Chem. compn. requirements and sampling methods are given. Min. CaO content is 92% and max. MgO 3%. E. N. B.

10. Tentative methods of chemical analysis of limestone, quicklime and hydrated lime. ANON. *A. S. T. M. Tent. Stand.*, 277, **1922.**—Details are given for estimation of SiO_2, Fe_2O_3, Al_2O_3, CaO, MgO, SrO, volatile matter, H_2O, CO_2, SO_2, total S, phosphorus, manganese, available lime. E. N. B.

11. Characteristics for the evaluation of limestone, dolomite and similar carbonate rocks and a rapid method for analyzing the same. A. DESGRAZ. *Z. angew. Chem.*, **35,** 714–5(1922).—The attempt is often made to judge a limestone by measuring the vol. of CO_2 evolved on treatment with an acid or by the loss on ignition but these tests often lead to erroneous conclusions. Sometimes an impure $MgCO_3$ will give the same CO_2 content as a pure $CaCO_3$ and often substances are present which lose water on ignition. The loss on ignition together with the behavior on slaking gives a better characterization. A pure calcite will give 41–44% loss on ignition, will slake rapidly and give a white oxide. A dolomite will give higher loss on ignition and a more grayish oxide which will not slake as readily. Calcite contaminated with much Fe and Al will show a lower loss on ignition and a yellowish oxide. The following very rapid method of analysis gives excellent values for CaO and MgO. Dry the sample at 110° and heat 1 g. to const. wt. at 930–950° to get the loss on ignition. Slake the residue with a few drops of water and transfer to a 150-cc. beaker. Boil with 30 cc. of a concd. soln. of NH_4Cl until no more NH_3 is evolved; this shows that all of the Ca and Mg has dissolved as chloride. Filter into a 500-cc. calibrated flask, ignite and weigh the residue of Al_2O_3, Fe_2O_3, Mn_3O_4 and SiO_2. In 100 cc. of the soln. det. the Ca by pptn. with $(NH_4)_2C_2O_4$ in the usual way. In another 100 cc. of the chloride soln. det. Mg without removing Ca by adding 10 cc. of 10% citric acid soln., 50 cc. of concd. NH_4OH and 30 cc. of 0.5% $(NH_4)_2HPO_4$ at 80°. Cool with running water, filter, wash with 2.5% NH_3 soln., ignite and weigh as $Mg_2P_2O_7$. W. T. H. (*C. A.*)

12. Aluminous cement. BIED. *Rev. univ. mines*, July, **1922;** *Technique moderne*, **14,** 508–9(1922).—Aluminous cements are cements with a high Al_2O_3 content, known commercially as "fused," "elec.," or "electro-fused" cement, in which the Al_2O_3 content is equal to or greater than the SiO_2 content. They are produced by fusion because Ca aluminates do not soften and clinkering is very difficult. Methods of manuf. are described. The compn. is about: SiO_2 10–12, Al_2O_3 40–45, CaO 35–40, FeO 15–20%. Setting starts in about 4 hrs., and is complete in 7–8 hrs. Hardening is very rapid and an ordinary concrete (800 l. gravel, 400 l. sand, 350 kg. cement) has a min. strength of 300 kg. per cm.^{2} in 72 hrs., which is much higher than the strength of Portland cements after 90 days. Also in *Rev. metal.*, **19,** 759–64(1922). A. P.-C. (*C. A.*)

13. Caustic magnesia cement. ANON. Bur. of Standards, *Circ.* **135,** 1–14 (1922).—General information concerning this type of cement is given, including discovery, early history, methods of manuf., and use for flooring, stucco, and ship decking. Considerable confusion has arisen because of the variety of names under which the material has been sold and variations in its quality and behavior. Recently a committee representing a Western organization of producers and two of the Federal bureaus has been organized to write specifications. Color, fineness, time of set, modulus of rupture, and constancy of vol. are being considered. Chem. requirements have been omitted. J. C. W. (*C. A.*)

BOOKS

14. Manufacture of Portland Cement. ARTHUR C. DAVIS. 3rd Ed. Revised and enlarged. Dublin: J. Falconer. 429 pp. 25s. (*C. A.*)

15. Cements and Artificial Stone. J. WATSON. Edited by R. H. RASTALL. Cambridge: W. Heffer & Sons, Ltd. 131 pp. 6s. (*C. A.*)

16. Cements, Limes and Plasters. EDWIN C. ECKEL. 2nd Ed. Revised and enlarged. New York: John Wiley & Sons. $6.50. Reviewed in *Eng. Mining J.-Press.*, **114**, 1126(1922). (*C. A.*)

Glass

17. Glass-making sand. (New Zealand.) ANON. *Raw Mat. Rev.*, **2**, 93(1923).—Deposits have recently been discovered by accident at Mount Somers, Canterbury. Prospecting had been in progress for about 12 mos., with a view to locating coal seams within easy access of the Gov't railways. After a 7-ft. drive had been made to a length of 400 ft., it was proved beyond doubt that an immense body of silica was present. Analysis shows that the sand is almost pure silica, containing no less than 99 per cent, a percentage never recorded before in any part of the world. Experts from glass-mfg. concerns have also examnd. the sand, and declare it to be the finest they have seen. O. P. R. O.

18. Pyrex glass. ANON. *Chem. Zeit.*, May 25, **1922.**—Pyrex glass is remarkably resistant to changes of temp., and may be used over an open fire. Expts. show that ordinary heating is not sufficient to melt the materials for such a glass, and a special furnace, possibly with surface combustion is required. Chem. compn. of Pyrex: Silica, 80.71; boric anhydride (B_2O_3), 10.47; alumina, 3.55; lime, 0.70; magnesia, 0.57; soda (Na_2O), 4.14. The low alkali content is noteworthy. O. P. R. O.

19. Glass and metal. W. E. S. TURNER. *Metal Ind.* (London), **22**, 128(1923).—Glass manuf. processes were contrasted with those in steel manuf. in a lecture given by Mr. Turner to the Sheffield Association of Metallurgists and Metallurgical Chemists, "Some Problems Common to the Study of Glass and Metals." Furnaces are similar, except that in the glass furnace the great desideratum is an oxidizing atm., while in the metal furnace it is a reducing atm. The conditions of working out are different in that the plastic glass can be worked direct into the article required and is not cast in ingot form, except in optical glass, and even then the glass is not teemed. The study of glass might assist in a number of interesting problems connected with hardening of metals. The cryst. forms of silicates have a distinctly different sp. ht., d., hardness and other properties from vitreous, and Mr. Turner suggested points of value in this connection. He further contrasted corrosion of glass and metals, and pointed out that a surface like glass appeared not to be homogeneous when subjected to chem. agents. O. P. R. O.

20. Use of the autoclave method in testing glassware. W. L. BAILLIE. *Glass Worker*, **42** [17], 13(1923). (From *Pottery Gazette and Trade Rev.*)—The autoclave test is reliable and expeditious, and its acceptance as a standard is urged. Three tests of increasing severity are 2 hours at 30 lbs., per sq. in., 3 hours at 50 lbs., 3 hours at 90 lbs. Should be made on finished piece and not on ground glass. The criteria of durability are alkalinity, clouding or superficial disintegration and the amount of residue on evaporation. R. J. MONTGOMERY

21. Some criticism of the use of the autoclave as a method of testing glassware. W. H. WITHEY. *Glass Worker*, **42** [17], 13(1923) (From *Pottery Gazette* and *Glass Trade Rev.*)—Tests on a zinc and a lime borosilicate glass showed inaccurate results, because the lime glass developed a protective coat on its surface which retarded action. The zinc glass did not do this. R. J. M.

22. Some difficulties of the interpretation of autoclave results. W. E. S. TURNER AND F. W. HODKINS. *Glass Worker*, **42** [17], 13(1923). (From *Pottery Gazette and Glass Trade Rev.*)—Results of test made at over 60 lbs. pressure are hard to interpret. As a

test for optical glass, the autoclave was insufficient as results were misleading. The boiling water test on crushed glass is as good and much more simple. R. J. M.

23. Chemical deposition of silver on mirrors. ALBERT S. CARTER. *Glass Worker*, **42** [18], 13(1923). (From the *Carnegie Technical, Jr.*)—Electroplating is satisfactory for metallic mirrors but not for glass. Chloride electrolyte is 3780 grs. H_2O, 85 grs. AgCl, 226 grs. NaOH or KOH, potential $^1/_2$ volt. Nitrate electrolyte, 100 grs. H_2O, 3 grs. $AgNO_3$, 3 grs. HNO_3, 3 grs. $C_4H_4O_6H_2$, 2 grs. $Fe(NO_3)_3$, potential 1 to $1^1/_2$ volts. Careful cleaning of the surface is necessary. A variation of the Edel process and the Brashear process are given for chemical deposition of silver. Various solutions and methods are given. R. J. M.

24. Decorated glass beads. ANON. *Schnurpfeil's Rev. for Glass Works.*, **6** [69], 1407 and **7** [70], 1439.—Descriptive article on bead making in Bohemia. Method of making and decorating is given for Coupé, Rocaillis, Macca and Thuringan types. R. J. M.

25. British glass industry; its development and outlook. W. E. S. TURNER. *J. Soc. Glass Tech.*, **6**, 108–46(1922).—Presidential address, containing an acct. of the history of the industry with statistics as to number of factories, workmen, production, exports, imports, etc. The British industry was an off-shoot of the continental and amounted to little until fostered by monopolies granted by Queen Elizabeth. In spite of oppressive taxation and regulation up to 1845, the century after 1775 was a prosperous one for the industry which reached the culminating point in 1874. Then until 1914 it struggled along under the handicaps of foreign protective legislation and foreign competition. The War, of course, forced the production of optical, chemical, and other glassware, previously almost entirely imported, and left the industry much better equipped than before. To England belongs the credit for first substituting coal for wood, for introducing covered pots, annealing in leers, open and shut molds, for discovering lead glass, and for developing the first bottle machine. Recently the industry has been revolutionized by the introduction of semi-automatic and automatic machines, largely American, and by the substitution of scientific for rule of thumb methods. Trained chemists and engineers are now being employed, research institutes have been established and a scientific Society with nearly 700 members has grown up. It is pointed out that future prosperity depends on stimulating the home market, extending the use of glass for containers, cooking, etc. The address closes with an eloquent description of the industry as a growing lad, dependent on its own energy and enterprise, lacking experience and confidence, needing criticism and help, but with no small latent power. G. F. FULCHER

26. Problems in the melting of glass II. (Discussion.) *J. Soc. Glass Tech.*, **6**, 147–56(1922).—(1) *Best ratio of cullet to batch.* When batch alone is used, the glass takes longer to plain and is also somewhat softer. It may contain very fine seed which affects its working properties. The cullet contains more iron and more alumina than the batch, therefore makes the glass more colored and more viscous, but it helps in plaining. Practice varies widely, depending largely on the amount of cullet available. In the case of tank furnaces, the important thing is to keep the ratio constant so that the properties of the glass will not change. (2) *Salt-cake vs. soda-ash in soda-lime glass batches.* Although no scientific explanation is at present available, it is a matter of experience that glass made from batch containing salt-cake is easier to work, and apparently has a longer viscosity range than if soda-ash alone is used. It was suggested that this is due to greater homogeneity. It is American practice in making window glass to use 1 part salt-cake to 2 parts soda-ash. However, the salt-cake is more corrosive of the refractories and sometimes gives a bluish green color. (3) *Advantages of thoroughly mixing batch and cullet* were pointed out, to insure homogeneity of the glass. (4) *Equipment needed for control of window glass tank* is listed. G. F. FULCHER

27. Columnar structure in sandstone tank blocks after rapid heating and cooling. JOHN CURRIE. *J. Soc. Glass Tech.*, **6**, 156–60(1922).—Blocks forming the lower course of the walls of a green bottle glass tank, became rapidly heated from about 800° to 1300° during the draining of the tank and were then rapidly cooled. They were found to show a columnar structure normal to the cooling planes, similar to that of basaltic columns. Four photographs are reproduced. G. F. FULCHER

28. Medieval glass of York Minster. W. FOXLEY NORRIS. *J. Soc. Glass Tech.*, **6**, 160–7(1922).—York Minster contains 109 windows with over 25,000 square feet of English glass of the 13th, 14th and 15th centuries. During the War, 23 windows were removed for preservation against destruction by raids, and it was then found that the windows were in a dangerous condition because of the disintegration of the lead, and also that the glass seemed to be diseased, many pieces being badly pitted and some having scaled off until they were paper thin; others had crumpled to dust. The windows were being gradually cleaned and releaded, the mellowing effect of centuries of dirt being removed but the original brilliancy being restored. W. E. S. Turner explained the disease as due to a *gradual hydration of the glass*, which was doubtless a lime glass made from French sand with perhaps not much alumina. G. F. FULCHER

29. Production of colorless glass in tank furnaces, with particular reference to the use of selenium. Part I. A. COUSEN AND W. E. S. TURNER. *J. Soc. Glass Tech.*, **6**, 168–81(1922).—A large number of small scale melts of a simple soda-lime-glass made with soda-ash showed that if the iron content is .09% or less, a colorless glass may be produced by adding .003% of selenium together with .0005% cobalt oxide. However, with even a small amount of salt-cake in the batch an increased amount of selenium was required. The salt-cake seems to react with selenium at high temperatures, producing sodium selenite, and it also tends to increase the iron content by corrosive action on the pot or tank walls. With batches containing soda-ash only, sodium selenite is about ten times more effective in decolorizing action than elementary selenium but this is not true of batches containing salt-cake. Reheating, and presumably annealing, decolorized glass does not introduce color, but over-decolorized glasses may have the amber tint deepened by heating at 525–575°. Further experiments are proceeding to determine more definitely the relative value of selenium and of sodium selenite as decolorizers and also the influence of reducing agents, including white arsenic.

30. Critical review of the provisional specifications for glass refractory materials. W. J. REES. *J. Soc. Glass Tech.*, **6**, 181–204(1922).—(1) *Silica brick.* For bricks to be used in such positions as furnace pillars, it might be well to specify a powder density of 2.35 so as to insure at least 80% conversion into tridymite; but for bricks to be used in crowns such a stipulation may not be necessary or desirable. A specification as to mechanical strength would be desirable. It was pointed out that exposure to a moist atmosphere diminishes the mechanical strength markedly. Special specifications for bricks to be used in regenerator chambers are also needed. (2) *Tank blocks.* There is great need for more information as to the causes of block failure, whether due to the particular melting conditions or to the materials or manufacture of the block. In some tanks the corrosion is not greatest at the metal line but may be worse on the lower blocks, due probably to mechanical corrosion. Tanks should always be raised to a high temperature before the filling is begun. The two most important factors governing the life of a block are porosity and uniformity of texture. Results of tests of 8 makes showed that the two blocks with porosity of only 21 and 19% and with after-contraction of only 1.4 and 0.8% gave the best service, one lasting 18 months in a tank furnace melting a salt-cake batch. The grog should be of the same clay or at least have the same solubility as the rest of the block. Perhaps unweathered clay would be better than weathered clay. Methods of test are discussed. A small special tank seems best. The practical

difficulties of producing uniform blocks are very great. Coöperation between block makers and users is necessary for best progress. In the discussion, it was suggested that since small blocks are more easily made uniform than larger ones, they should be tried. (3) *Pot clays.* The specifications are decidedly debatable. Though there is a tendency to use aluminous clays, siliceous clays give greater strength and show less shrinkage. G. S. F.

31. Manufacture and properties of oven glass. R. F. BRENNER. *Glass Ind.*, **4,** 23–4(1923).—Glass to be satisfactory as a material for ovenware, must have high thermal endurance, high chem. stability, high mech. strength, and good workability. The various oxides exert a favorable influence on the important properties in the following order, the best coming first: Tensile strength—ZnO, SiO_2, P_2O_5, B_2O_3, BaO, Al_2O_3, As_2O_3, PbO, Na_2O, K_2O; expansion—B_2O_3, MgO, SiO_2, ZnO, P_2O_5, As_2O_5, PbO, BaO, Al_2O_3, CaO, K_2O, N_2O; elasticity—MgO, As_2O_5, B_2O_3, SiO_2, BaO, CaO, K_2O, Na_2O, ZnO, Al_2O_3. Stability is high for borosilicate glasses of low alkali and high silica content, especially when containing alumina. While low expansion is desirable, the other factors must also be considered. G. S. F.

32. Making of watch crystals. W. H. HOLMES. *Glass Ind.*, **4,** 25–28(1923).—When the war stopped the importation of crystals, the Waterbury Watch Company undertook to make their own and gradually developed a plant which now has a capacity of over 100,000 crystals a day. A lead glass batch made with crushed silicate rock, is melted in covered 2400 lb. pots and then blown off-hand, without molds but with compressed air, to spherical globes, 10 to 12″ in diameter. These are split, then circular blanks are cut out, inspected, graded, reheated if necessary to level the edges, then the edges are ground and polished by semi-automatic machines. Higher grade crystals are specially shaped, ground and polished. G. S. F.

33. Operating continuous glass furnaces with fuel oil. W. G. EDMONDS. *Glass Ind.*, **4,** 29(1923).—A discussion of the relative cost of coal and fuel oil, with suggestions as to the storage of the oil and the operation of the oil burners. G. S. F.

34. Glass manufacture with the electric radiation furnace. V. M. SAUVAGEON. *Glass Ind.*, **4,** 30–1(1923). Trans. of *Chimie et Industrie*, **7,** 452–5(1922).—(See *Ceram. Abs.*, **1** [9], 82(1922). G. S. F.

35. Making glass for Ford windshields. FRED S. HUNTLEY. *Glass Ind.*, **4,** 1–5 (1923).—Illustrated description of the one furnace plant at Highland Park which is at present supplying 7 per cent of the Ford windshields required. The soda lime glass flows continuously on to a moving table which takes it under nichrome rolls and then through a 442 ft. leer. After cutting, each plate is embedded in plaster of Paris (mixed continuously in a special machine) and carried in succession under seven sand grinders, five emery grinders and a rouge polisher. The other side is then polished in the same way. Experiments to produce windshields without polishing were carried on for two years but finally given up. Construction of a four-furnace plant at River Range has just begun. G. S. F.

36. Use of fuel oil for finishing glassware. W. S. EDMONDS. *Glass Ind.*, **4,** 4–5(1923).—Some suggestions for the use of oil burners in glory holes. A dry flame should be used so that carbon may give a polish to the glass. The burner should be placed in the center of the bottom and only sufficient draft used to show a little white smoke leaving the stack. G. S. F.

37. Burnt lime or limestone in glass batches. IRVING E. ADAMS. *Glass Ind.*, **4,** 5(1923).—Comparative runs are cited which indicate that while coarsely crushed high magnesia limestone tends to give seedy glass, burnt lime is no better than finely ground limestone. Practice at present varies, burnt lime being used for bottles, tumblers, lamp chimneys, etc., while limestone is used for fruit jars and window glass. The *value*

of salt cake, 60 or 70 lbs. per batch, over straight soda-ash charge in accelerating plaining, is confirmed by a test. G. S. F.

38. Modern glass factory equipment. W. S. MAYERS. *Glass Ind.*, **4**, 7–8(1923).—Brief discussion of modern equipment for storing and handling raw materials, for mixing the batch and for conveying it to the furnace bins. The arrangement in which the batch car runs under the storage bins and discharges into an elevating and conveying system extending to the furnace bins is the most flexible. To avoid sepn. of fine and coarse materials in the furnace bin, a special design is suggested which provides plates to divide the bin into narrow vertical shutes. See *Ceram. Abs.*, **2** [2], 31(1923). G. S. F.

39. Notes on glass etching. J. B. KRAK. *Glass Ind.*, **4**, 10–11(1923).—Description of methods of producing clear and frosted etchings, with recipes for etching solutions. G. S. F.

40. Leers. W. S. MAYERS. *Glass Ind.*, **4**, 21–23(1923).—Discussion of various types, from kilns to continuous fixed pan muffle leers. Most present leers are very wasteful and inefficient but while elec. heating gives better control it is too expensive. G. S. F.

41. From manganese to selenium. I. E. ADAMS. *Glass Industry*, **3**, 219–20 (1922).—Instructions are given for changing a tank of glass from one decolorizer to the other. The following batch is included for narrow neck machine-made bottles: sand 1000, soda 390, burnt lime 110, arsenic 2, borax 2, cullet 700, decolorizer mix as needed. J. B. P.

42. Measurements on the gases evolved from glasses of known chemical composition. J. E. HARRIS AND E. E. SCHUMACHER. *Ind. Eng. Chem.*, **15**, 174–7(1922).—Glasses whose compns. run high in alkali give off more gas during their heat treatment than do those of lower alkali content. A definite relation appears to exist between the amt. of water vapor held by a glass and its alkali content. A relation, although not as pronounced as that mentioned above, appears to exist between the amt. of CO_2 held by a glass and its alkali content. Adsorbed CO_2 seems to be held to a glass primarily by primary valence forces. Adsorbed permanent gases seem to be held to glass primarily by secondary valence forces. Glass relatively free from absorbed gas can be produced by heating the glass during its melting process to a sufficiently high temp. A bibliography of 39 titles follows the article. J. B. P. (*C. A.*)

43. Pyrex glass as a material for chemical plant construction. A. E. MARSHALL. *Ind. Eng. Chem.*, **15**, 141–4(1923).—A description of the development of Pyrex for industrial use particularly in chem. manuf. Tables of properties and sp. applications are included. A. E. M. (*C. A.*)

44. Sir William Crooke's anti-glare glasses. J. H. GARDNER. *Chem. News*, **125**, 375(1922).—Historical. J. B. P. (*C. A.*)

45. A modern annealing cycle. W. O. AMSLER. *Nat. Glass Budget*, **38**, No. 29, 1, 13, 24–5, 27(1922); 3 figs.—The work of the government glass chemists on optical glass during the war is applied to the annealing of commercial bottles in the modern muffle leer. J. B. P. (*C. A.*)

46. The application of calorizing to glass making processes. S. F. COX. *Glass Industry*, **3**, 243–5(1922).—Calorized gas burners, structural shapes and supports of furnaces, recuperator tubes, valves and dampers, bolts and accessories and pyrometer tubes for leers are suggested. J. B. P. (*C. A.*)

47. Conduction process in ordinary soda-lime glass. C. A. KRAUS AND E. H. DARBY. *J. Am. Chem. Soc.*, **44**, 2783–97(1922).—The replacement of Na in glass by other metallic elements has been accomplished by electrolysis. The anode from which the metallic element enters the glass may be either an amalgam or a fused salt. Usually the glass so formed by substitution of the second metal is unstable. Na has been re-

placed by Ag to a depth of about 0.1 mm. The speed of the ions increases greatly with the temp. The cond. of glass is due entirely to the movement of the metallic Na ions. About 75% of the ions are in a condition to conduct. The rest apparently are held rigid.
C. R. P. (*C. A.*)

Heavy Clay Products

48. Tentative specification for clay sewer pipe. ANON. *A. S. T. M. Tent. Stand.*, 232, **1922.**—Cover. I. Materials. II. Size. III. Sampling. IV. Chem. tests. V. Physical tests. VI. Usual inspection. E. N. BUNTING

49. Tentative specifications for required safe crushing strength of sewer pipe to carry loads from ditch filling. ANON. *A. S. T. M. Tent. Stand.*, 237, **1922.**—A table is given covering the crushing strength as a function of the kind of ditch filling material used, breadth of ditch, and height of fill above the top of pipe. E. N. B.

50. Tentative specifications for clay hollow building tile. ANON. *A. S. T. M. Tent. Stand.*, 262, **1922.**—Detailed physical test requirements are given for compression test, freezing, and fire test. Standard sizes, workmanship, marking, and inspection methods are also listed. E. N. B.

51. Tentative definitions of terms relating to hollow tile. ANON. *A. S. T. M. Tent. Stand.*, 318, **1922.**—Definitions are given of the several kinds of tile, the clays used in making tile, and the dimensions and parts. E. N. B.

52. Burning in up-draft furnace kilns. ELIAS PETTS. *Brick and Clay Record*, **62**, 125–6(1923).—P. mentions the usual considerations of all burning problems, namely speed with which fire may be advanced without damage to ware; condition of setting, whether damp or dry; and selection of fuel. A sketch is given of the platting of an up-draft furnace kiln and bricks to be removed before fires are started are marked in diagram. P. further discusses the closing of the platting as the firing increases, also remarks smaller grate surface and air spaces in grate are necessary when burning wood than for coal, and emphasizes keeping of the kiln too tight after it is hot. When using oil as a fuel in this type of a kiln, good results were obtained in an installation having one burner to a furnace and each furnace having two arches. J. W. HEPPLEWHITE

53. Coloration, discoloration and other burning effects. ELLIS LOVEJOY. *The Clayworker*, **79**, 38–9(1923).—A discussion of scumming. Many discolorations are due to S gases and condensation of moisture on the ware in colder parts of the kiln. Improvement and perhaps complete correction can be obtained from slower water smoking, better circulation, more open kiln bottoms and stronger draft. J. W. H.

54. Building drier over kiln. ALEXIS A. ZAKHAROFF. *Brick and Clay Record*, **62**, 415–7(1923).—Description of a drier built over a kiln and sketch of same is given. Cost figures are given, estimating cost of brick at $11.00 to $14.00 per thousand by this method. Z. cites practical hints in the construction of this system gathered from observations of brick plants of this type; such as insulating outside walls, min. number of windows for illumination, side windows create cross drafts, lines for transport care should follow outside walls and should not pass through the center of the installation.
J. W. H.

55. Fire flashing. ANON. *The Clayworker*, **79**, 156(1923).—Discussion not intended as an attempt to explain flashing but to present phenomena in so far as is known. Fire flashing is a color effect produced by reducing kiln atmospheres and faces to be flashed *must be in path of flame*. Best effects are produced at cone 3 to 9; preferably the latter temp. References made to contributions on this subject by H. B. Henderson and J. Parker B. Fiske. Russet color due to amber colored hexagonal plates which owe their development to carbon, likely graphitic carbon. Graphitic carbon present probably from cracked kiln gases especially methane. Graphitic carbon acts as a catalytic agent.

Time is essential for the growth of the hexagonal crystals. Ware which scums presents widest variation in color effects. Olive greens due to limey clays and saffrons attributed to S effects in the water smoking and in incomplete oxidation. J. W. H.

56. Plant design. ANON. *Brick and Clay Record*, **62**, 236(1923).—Description of layout of Cresent China Co. plant at Alliance, Ohio, is given, pointing out labor saving devices and arrangements. J. W. H.

57. A curious defect in salt glazing. ANON. *Brit. Clayworker*, **31**, 319–20(1923).—It was noticed that sewer pipe did not glaze at the sockets. In some cases the sockets were free from the glazes on the outside as well as the inside. Salting as high as seven times did not overcome this defect. This trouble was diminished by vigorous heating prior to salting. It was found that this trouble was really due to the irregular distribution of the draft in the kiln, and by enlarging the flue leading from the kiln to the chimney and building a floor which was uniformly perforated, instead of relying on the solid floor with a complex, yet evidently inefficient arrangement of bricks above it, the pipes were glazed uniformly. The perforated floor was built of fire bricks, arranged so as to leave as many openings, each 4 in. by $2^1/_2$ in., thus passing away at almost uniform rate through every part of the floors. A few of the openings near the center of the kiln were made rather smaller than the remainder so as to counteract the greater "pull" nearer the wall. H. G. SCHURECHT

58. Clay and cement tubing. H. BURCHARTZ. *Mitt. Materialprüfungsamt*, **39**, 15–53(1921).—New data are given for compression strength and resistance to internal pressure. The stability towards acids of clay tubes and the absorption of H_2O and permeability to H_2O of both clay and cement tubing are also given. The results of each individual test are reported in detail because the deviations for tubes of similar shape and material were so large that mean values are considered unreliable. Ruptures were variable, some occurring longitudinally, others both longitudinally and transversely with rough surfaces of varying colors. The tests included tubes of clay and stoneware of circular cross-section, cement of circular cross-section and flat base, cement without base, cement without joints, cement of egg-shaped cross-section and special forms. No law was found giving any relation between size and strength. All results are in kg. per sq. cm. *Clay tubes. External pressure.* The breaking load was 2500–4000 for 80% of the tubes, with 6% below this range. The mean values of all tubes (20 to 100 cm. inside diam.) lay between 3160 and 4090. The mean of all the av. values was 3580. *Internal pressure.* The mean value (tangential stress) of all tubes varied from 34.3 to 77.7. The mean of all av. values was 59.7. *Cement tubes. Circular tubes.* The breaking load was essentially 2500–5500, with only 8% below this range and 16% above. The highest breaking loads were 7600 and 7620 for 2 tubes of 40 cm. diam. The mean values for the various sizes varied from 2630 to 5280 and the mean of all averages was 4150. *Egg-shaped tubes.* The breaking load was for the majority 4000–7000 with 17% under and 21% over this range. A tube of 70/105 cm. inside-outside diam. gave 11,010. The mean values of all sizes were 4260–8200, and the mean of all averages was 5270. By the standard test, the soly. of most of the clay tubes in H_2SO_4 was 0.04–.08%, with 1 case of 0.23%. Cement tubes immersed in 0.5% HOAc, HCl, H_2SO_4 and HNO_3 showed surface attack, due to the Ca compds. present. H_2O absorption was 2.1–5.3% for clay tubes and 7.1–7.7% for cement tubes. Cement tubes were found both porous to H_2O and waterproof. Clay tubes were those with porous surface and a H_2O absorption up to 10% and stoneware tubes as those with a vitrified surface and H_2O absorption not over 5%. C. C. D. (*C. A.*)

Refractories

59. Tentative method of test for resistance of fire clay brick to spalling action. ANON. *A. S. T. M. Tent. Stand.*, 297, **1922**.—Bricks are given a preliminary heating

for five hrs. at 1400°C. One end is exposed in door of furnace to 1350°C for one hr., then removed and put in cold running water for 3 min. Alternate heatings and coolings are made until the end of brick spalls off. E. N. B.

60. Tentative method of test for slagging action of refractory materials. ANON. *A. S. T. M. Tent. Stand.*, 293, **1922.**—A fire clay ring is cemented with refractory cement on the brick tested, and a synthetic slag placed within the ring. The prepared brick is fired to 1350°C for 2 hrs. When cold the brick is broken through the center of the ring and the penetration and attack by the slag noted and measured with a planimeter. E. N. B.

61. Dry pressing refractory shapes. L. W. FLOOD. *Brick and Clay Record*, **61,** 865–6(1922).—Stiff mud process requires a large percentage of plastic material, the same holds true of the soft mud process except in the case of silica, magnesite and chrome, also soft mud process cannot be used for manuf. of large shapes unless some supports are placed around sides of shapes when taken from mold. A high percentage of plasticity is not essential for dry press ware since pressure at times is about 5000 to 6000 lbs. per square in. Plasticity, however, should be developed to the best practical degree in order to produce the best brick possible with least expense, trouble and loss. In some cases high plasticity may cause ware to split. The addition of grog, sand or calcined material assists in overcoming this trouble. Moisture content in dry press ware usually runs about 7%. Too dry a mixture causes difficulty in handling. Homogeneity of material is important. The clay should be fed to some type of screen before going through the pan, as too large a propn. of coarse sizes reduces the plasticity of the mass, even though the clay when properly ground may be classed as plastic. It also renders the propn. of good brick more difficult and expensive. A mech. mixer is necessary and should be placed just above the press to keep the fine and coarse particles properly mixed. The clay from the mixer should have a perpendicular chute into the press. It is advisable to use as high a pressure as is possible without producing pressure checks, as high pressure makes stronger brick. F. summarizes the advantages gained by making large shapes by dry press process as follows: 1. Cost of manuf. reduced. 2. Cost of installing expensive dryers or dry floors will be lessened. 3. Resultant ware will be more uniform and exact in size. 4. Refractoriness of some clays will be increased. 5. Uniform size of ware will reduce the fire clay used in the joints. 6. Large refractory shapes made by dry press process are able to withstand thermal shock much better than the same shapes made by another process. 7. Dry press ware is a poorer conductor of heat. A diagram of a section through model dry press plant showing most important features is given. J. W. HEPPLEWHITE

62. Improvement of refractories. ANON. *Brick and Clay Record*, **61,** 867(1922).—A survey is to be conducted by the Refractories Manufacturers' Association in coöperation with various committees. Survey will consume the better part of two years and will employ the use of an elaborate questionnaire distributed among consumers of refractory brick which will include blast furnaces, stoves and connections; open hearth furnaces and metal mixers; heating, puddling and forge furnaces, cupolas; malleable furnaces, oil refineries; gas plants; glass houses; by-product coke ovens; zinc, copper and lead refineries; boilers; cement, lime and plaster kilns and kilns for burning ceramic products. J. W. H.

63. The nature of graphite and amorphous carbon. GENSHICHI ASAHARA. *Sci. Papers Inst. Phys. Chem. Research*, **1,** 23–9(1922); *Japan. J. Chem.*, **1,** 35–41(1922); cf. Debye and Scherrer, *C. A.* **12,** 786.—The essential identity of graphite and amorphous C has been established by the *X-ray analysis of 34 different forms of C* from different sources. They were ground into fine powder and pressed to layers of about 1 mm. thickness. These were fixed in front of a small window of a wooden box contg.

a photographic plate and placed in a lead camera. The interference figure of the material was recorded on the plate as concentric rings, the plate cutting the mantles of cones of the diffracted rays. Six of these cameras were arranged conically, with the vertex in the source of X-rays facing the X-ray bulb in a shielded box. The interference figures thus obtained constitute an unbroken series, gradually altering from those with 6 comparatively sharp concentric rings of intensity maxima (Type I) to those with an indistinct halo of distributed intensity (Type III). Those whose intensity maxima are not sharply defined but broadened ill-defined bands (Type II) lie between the two extremes. Certain forms of graphite, such as Ceylon and Korean graphites, etc., gave figures with radiant streaks (Type IV), the intensity maxima being common to graphites appearing intact. The streaks may be attributed to the fact that these graphites are only ground along their flat cleavage faces and the incident rays fall chiefly and almost perpendicularly on their cleavage faces. The angles corresponding to the six concentric rings, which the diffracted rays make with the incident rays, are approx. 14°, 18° 50′, 22° 20′, 25° 40′, 31°, and 36° 30′, resp. The natural and artificial graphites, however finely they may be powd., possess a cryst. structure, as they plainly show sharply defined interference rings. Amorphous C also gives interference figures, but no distinct maxima are observed owing to the distributed intensity. Their estimated maxima are however invariably at about 14° and 23°. Carbons produced by the decompn. of certain gases or vapors, such as CO, C_2H_2, or CS_2, or Fe_3C and coal, gave no sign of definite crystalline form, but they gave definite interference figures which establish their cryst. nature. The word "amorphous" must, therefore, be replaced by "extremely minutely cryst."

K. K. (*C. A.*)

64. High-temperature melting. ANON. *Iron Age*, **110**, 1507(1922).—A description of the elec. furnace equipment of the rare metal alloy refining and melting plant of the Bario Metals Corp. The equipment includes 3 graphite resistance furnaces and 1 high-frequency induction furnace. L. J. (*C. A.*)

65. Ajax-Wyatt furnace in the brass-mill casting shop. R. P. HEUER. *J. Ind. Eng. Chem.*, **14**, 1021–4(1922).—A method is developed for calcg. the proportions of a vertical ring induction furnace which will result in a well-balanced mechanism. Operating procedure and furnace schedules are discussed and a comparison is made between induction furnace and crucible melting of brass in rolling mills. L. J. (*C. A.*)

66. A new induction furnace. J. M. WEED. *Trans. Am. Electrochem. Soc.*, **42** (preprint); *Chem. Met. Eng.*, **27**, 977–9(1922).—A description of a new type of induction furnace for melting non-ferrous metals (see *C. A.*, **16**, 3814). An explanation is given of the manner in which the magnetic forces establish max. and min. fluid pressures at opposite ends of the secondary cylinder and maintain a unidirectional circulation of metal.

L. J. (*C. A.*)

67. A new cupola lining. KARK GROCHOLL. *Die Giesserei; Iron Age*, **110**, 1279 (1922).—In Germany a loose refractory mixt. is being used for ramming up the cupola lining, instead of fire brick and blocks. The cost is only $^1/_{10}$ that of fire brick. Patching is done after every heat, with unskilled labor, and a new lining is not required within 2 yrs. A. B. (*C. A.*)

68. Bavarian graphite. EUGEN RISHKEVICH. *Chem.-Ztg.*, **46**, 1013–6, 1035–6 (1922).—The graphite occurs in gneiss, replacing mica and associated with pyrite. It varies from 12 to 40%, usually 20 to 25%, C content, that under 12% not being worth mining. The ore comes in lenses, and mining is expensive. Crushing, sizing and wet concn., followed by fine grinding and concn., give a concentrate of 65% C, which can be raised to 80–90% by dewatering. Tests are described indicating the superiority of Bavarian graphite in elec. cond., heat cond., resistance to combustion, etc., when compared with other kinds. W. C. E. (*C. A.*)

69. Cement kiln insulation. P. C. DURBIN. *Concrete* (Mill Section), **22,** 2–4 (1923).—The advantages of an efficient insulating material in a cement kiln are: (1) a marked saving of fuel, (2) better working conditions, (3) longer life of shell and auxiliary equipment, (4) longer life of refractories, (5) more uniform distribution of heat, (6) ease of temp. control and (7) conservation of unused heat for power production.

J. C. W. (*C. A.*)

70. A new refractory material. W. SMITH. *J. West Scotland Iron and Steel Inst.*, **30,** 8–13(1922).—The new refractory is *carbonized clay.* Mixts. of C and clay are old but carbonizing by C-charged gases has never been well developed. Charging is done when the clay is in the biscuit state and at max. porosity. Shrinkage, with higher burning, then compresses the C to a d. comparable to that of steel. So long as carbonized clay remains in a reducing atm. it will withstand the highest com. temps. and is unaffected by acids. Much skill is required in the carbonizing process. Ground raw clay and coal are heated together in a muffle kiln. The evolved gases may be used for fuel and coke is obtained. Pitch may be used as a binder in forming shapes of carbonized clay. There is no after-contraction. White carbonized clay is made by burning out the C in carbonized clay. The black is suitable for heat resistance in a reducing atm., for acid-resisting ware and for abrasives. The white is suitable for heat resistance in an oxidizing atm. Carbonization may be a means of extracting Fe and alkalies from clays. The reports are based upon lab. tests. Com. tests will be made. C. H. K. (*C. A.*)

BOOK

71. A comparison of British and American Foundry Practice. P. G. H. BOSWELL. Liverpool, England: University Press of Liverpool, Ltd. Cleveland: The Foundry. 106 pp. $1. Reviewed in *Foundry,* **51,** 11(1923). (*C. A.*)

Whitewares

72. American and English Ball Clays. H. H. SORTWELL. Bureau of Standards, *Tech. Papers* **227.**—The 21 ball clays being used in the largest quantities in the manufacture of china, semiporcelain, elec. porcelain, sanitary ware, and floor and wall tile were studied at the Bureau of Standards. Detns. were made of the water of plasticity and shrinkage relations upon drying, amount of arenaceous material retained by 120-mesh sieves, rate of flow of slips, cohesion of the plastic clay, dry transverse strength when mixed with an equal part of flint, time required for oxidation of carbonaceous material at 75°C, porosity and vol. changes from Orton Seger cone 01 to cone 12, and coloring effect in a standard body. No great differences were noted in water of plasticity, all of the clays falling within a range of a few per cent. The Dorset clays showed a slightly higher drying shrinkage than the other clays studied. All of the clays showed a tendency to warp in drying but none developed cracks. The Amer. clays were much cleaner than the English and contained less coarse mineral matter and dirt which would be removed in lawning the body after blunging. The Ky. clays were almost free from such material, and the Tenn. clays contained only a small amount, while the English clays were less desirable in this respect. The transverse strength of equal mixts. of the clays with commercial potters flint was detd. to give a better indication of the comparative bonding power of the clays in a body than would be indicated by the modulus of rupture of the clay alone. The average modulus of rupture of the Tenn. clays tested was 366 lbs. per square inch, the Ky. clays averaged 282 lbs. per sq. in., the clays from Dorset, Eng., 405 lbs. per sq. in., the Devonshire clays 443 lbs. per sq. in., and English clays, whose exact source was not known, 419 pounds per square inch. In general the English clays were stronger than the domestic, but two of the Amer. clays compared favorably with the average English clay. From the results obtained the rate of flow of slips from the

efflux viscosimeter did not appear to be a valuable criterion of the inherent plastic qualities for use in comparing ball clays. Sol. salts in the clays probably affect the results. The cohesive strengths of the plastic clays were determined at different water contents and are shown graphically. These results showed no distinctions which compared with the value of the clays for jiggering as judged by practical potters. Some of the English clays are very high in carbonaceous matter, 11 hrs. being required in two cases to completely remove the black core from specimens $1^1/_4$ by $1^1/_4$ by 2 in. The clays from Devonshire as a class required the longest time for oxidation. The Dorset clays and those from Tenn. contained a moderate amount of carbonaceous matter while the Ky. clays contained but little. It was noticed that there was a relationship between the amount of carbonaceous matter and the strength when dry, the more carbonaceous clays usually being stronger. The burning behavior of the American and English clays was radically different. The English clays vitrified at a low temperature and remained almost constant in porosity and volume up to cone 12. No evidence of overburning was noticed at that temperature. There was some variation in the burning behavior of the clays from Devonshire, but the Dorset clays underwent practically the same changes in firing. The American clays showed a gradual reduction in porosity from cone 01 to cone 12. Tenn. ball clay No. 5 was the only domestic clay which vitrified at cone 8. Tenn. No. 3 matured at cone 10, and Tennessee No. 11 and Kentucky No. 4 at cone 12. The other two Kentucky clays studied were not vitrified at cone 12. Throughout the firing range studied the American clays were constantly changing in volume. In the standard body the Tennessee clays as a class showed the best color. The Ky. and Devon clays were fair in this regard while the Dorset clays were comparatively poor in coloring effect. Although the English clays have a more desirable firing behavior and greater strength when dry, the American clays contain less material to be removed in body prepn., contain less carbonaceous matter which may lead to trouble in firing, and burn to a better color in the body. Because of their better color they may be used in larger quantities, thereby overcoming in a measure their lower strength. With a slight adjustment in flux content of the body they may be successfully used to replace the English clays. A classification of ball clays based on their properties has been drawn from the results of the work. The complete paper may be purchased from the Supt. of Documents, Government Printing Office, Washington, D. C. H. F. S.

73. Studies of changes in the physical properties of a hard porcelain caused by varying the feldspar from Na to K feldspar and by varying the burning treatment. E. ROTH. *Sprech.*, **55**, 533–4(1923).—Porcelains of the following general compns. were studied: clay 50, quartz 25 and feldspar 25. R and Na feldspars of the following compns. were used.

Six	K feldspar	Na feldspar
SiO_2	64.3%	67.1%
Al_2O_3	19.4%	20.3%
Fe_2O_3	0.1%	0.3%
CaO	tr.	0.8%
MgO	0.4%	tr.
K_2O	12.9%	tr.
Na_2O	2.1%	11.8%
Ignit. loss	0.6%	0.1%

Various mixts. of Na and K feldspars were studied varying from pure Na feldspar on one extreme to pure K feldspar on the other. Porcelains prepd. with these feldspars were fired to cones 9, 11–12, 13, 14, 15, 15–16. A study of the thin sections showed that at 1120°C the feldspar melted. Upon increasing the temp. a portion of the clay substance goes into solution and the sillimanite crystallizes out. The coarse grains of crystalline

quartz do not go into solution until a temp. of 1480–1500°C are reached. Upon further heating the sillimanite crystals are taken into soln. until at 1600°C a homogeneous body is obtained. The following conclusions were drawn: (1) The K rich porcelains produce bodies having a higher viscosity than the Na rich porcelains. (2) The saturation of Na and K feldspar with clay substance was determined by means of the indices of refraction of the glass. It was found that the K feldspars dissolved 20% clay and the Na feldspar dissolved 15% clay. (3) The solubility of silica in the glass depends upon the size of grain, cryst. modification of Si and the firing temp. (4) Na feldspar exerts a stronger soln. action upon silica than K feldspar. (5) Maximum shrinkage occurred at cone 9 and above this temp. the mass commenced to swell. (6) The sp. grs. of both the Na and K bodies decreased with an increase in firing temp. (7) The linear coeff. of expans. decreased up to cones 11–14. Since the thin sections showed that at this temp. the K body had not and the Na body had only slightly dissolved the coarse quartz grains, it seems that the finely dispersed Si resulting from the dissociation of the clay is dissolved by the glass. With the Na body the decrease in expans. is very marked at this temp. (8) The translucency increased up to cones 12–14. The translucency remains about the same between cones 12–14 but when fired about cone 14 the coarse quartz grains are dissolved and the translucency increases. The Na bodies are slightly more translucent than the K bodies. (9) The impact cross-breaking test and the ball compression test gave a max. at the temp. where max. shrinkage and density is developed. Between cones 12 to 14 a small decrease in strength is obtained and above cone 14 an increase was again developed. (10) Both the K feldspar and the Na feldspar bodies gave a dielectric constant of 5.8. The elec. penetration depends largely upon the porosity of the body. H. G. SCHURECHT

74. Antimony yellow glazes. W. ROHN. *Keram. Runds.*, **31,** 31(1923).—A study was made of cone 3*a* Sb yellow Pb glazes. The success of this type of glaze depends upon (1) the constituents in the glaze, (2) an oxidizing kiln atmos., and (3) a cer-

ANTIMONY YELLOW LEAD GLAZES

1.	0.80 PbO, 0.20 K_2O	0.15 Al_2O_3 2 SiO_2 + 3% HSb_2O_3, nice yellow, 6% HSb_2O_3, dirty (ocher yellow)
1*a*.	0.80 PbO, 0.20 K_2O	0.15 Al_2O_3 { 2 SiO_2, 0.4 B_2O_3 } + 3% HSb_2O_3, nice yellow
2.	0.80 PbO, 0.20 Na_2O	0.15 Al_2O_3 2 SiO_2 + 3% HSb_2O_3, very nice yellow, 6% HSb_2O_3 or SnO_2, dirty color
2*a*.	0.80 PbO, 0.20 Na_2O	0.15 Al_2O_3 { 2 SiO_2, 0.4 B_2O_3 } + 3% HSb_2O_3, beautiful yellow, 6% HSb_2O_3, dirty color
3.	0.80 PbO, 0.20 MgO	0.15 Al_2O_3 2 SiO_2 + 2% HSb_2O_3, yellow, 4% HSb_2O_3, dirty, 3% pale yellow
4.	0.80 PbO, 0.20 BaO	0.15 Al_2O_3 2 SiO_2 + 3% HSb_2O_3, pale yellow
5.	0.80 PbO, 0.20 CaO	0.15 Al_2O_3 2 SiO_2 + 3% HSb_2O_3, pale yellow
6.	0.80 PbO, 0.20 SrO	0.15 Al_2O_3 2 SiO_2 + 3% HSb_2O_3 almost white, 5% HSb_2O_3, same as with 3%
7.	0.80 PbO, 0.20 ZnO	0.15 Al_2O_3 2 SiO_2 + 3% HSb_2O_3, yellow, with 5% HSb_2O_3, dirty

tain transparency of the glaze. Excellent results were obtained with glazes having an RO composed of 0.8 to 0.9 PbO and 0.1 to 0.2 KNaO. Good colors were also obtained with glazes having an RO composed entirely of PbO. Extra good colors were obtained

with glazes having 0.1 to 0.2 Na_2O and 0.8 to 0.9 PbO. This compn. produced Neapolitan yellow shades. The alkali earths on the other hand destroy the yellow color with the exception of MgO. Although MgO prevents to a certain extent the formation of the desirable Neapolitan yellow shades it does not destroy the yellow color as CaO does. BaO acts very similar to CaO while a glaze containing 0.8 PbO and 0.2 SrO_2 produces a white glaze entirely destroying the yellow color. ZnO, Al_2O_3 and SiO_2 do not have much influence on the yellow color. B_2O_3 does not affect the color but gives the glaze a high gloss. Glaze 2*a* shown in the table produces a bright egg-yellow color which is not possible to obtain with a glaze free from B_2O_3. The addition of a small percentage of Fe_2O_3 to a yellow glaze produces an orange-yellow. Opalescent-yellow glazes have a dirty color being similar to China-reds in this respect. 1 to 3% HSb_2O_3 gives best colors. The addn. of 6% SnO_2 to a yellow glaze changes its color to ocher. With alkali earth free glazes yellows are obtained above 0.35 PbO. By changing the Al_2O_3 and SiO_2 contents glazes suitable for stoneware may be prepd. These glazes may also be used for china painting. By varying the PbO and Sb_2O_3 contents a series of colors varying from sulphur-yellows to orange-yellows may be prepd.

H. G. SCHURECHT

75. Sagger investigation. ANON. *Brick and Clay Record*, **61**, 960(1922).—Bureau of Standards are testing 52 different sagger clays sent by the consumers in order to locate the causes of sagger losses. Clays for classification purposes will be tested for water of plasticity, shrinkage, porosity, transverse strength and burning behavior at 5 different cones. J. W. H.

76. Report of committee D-9 on electric insulating materials. F. M. FARMER, *et al. Proc. Am. Soc. Testing Materials*, **22**, I, 472–8(1922).—Recommendations for slight changes in present tentative methods and an outline of work during the yr.

C. C. D. (*C. A.*).

Equipment and Apparatus

77. Heat insulating materials for electrically heated apparatus. J. C. WOODSON. *Trans. Am. Electrochem. Soc.*, **43**, preprint(1923).—While there are numerous grades of heat insulators, none can compare with elec. insulators. Of all the various grades there are only a few basic materials used. True insulation value lies almost entirely in the entrapped dead air spaces of the structure, and this goes back to the phys. structure of the cell or crystal. Working temp. ranges may be grouped under 5 divisions below 93°, 93–177°, 177–315°, 315–538°, 538–1093°. To cover these temp. ranges, practically all com. grades of insulators can be grouped into 3 classes as follows:—Class *A*, —18° to 93°, hair, wool, felt, wood pulp, animal and vegetable fiber, asbestos paper and cork; Class *B* (most important), 93–538°, magnesia, sponge, earths, mineral wool and asbestos; Class *C*, 315–1093°, diatomaceous earth, mineral wool, earths and silicates. Since the law of heat flow is analogous to Ohm's law 2 formulas are given. For flat surfaces with the customary units the formula is: $Q = KAt\ [(T_1 - T_2)/d]$, where Q = B. t. u. transmitted, A = sq. ft., t = time in hrs., d = thickness in inches, $T_1 - T_2$ = °F, and K = coeff. of thermal cond. = B. t. u. per sq. ft., per inch of thickness, per hr., per Fahrenheit degree. For cylindrical surfaces $Q = \dfrac{K(T_1 - T_2)}{R \log_e (R_2/R_1)}$, where R_1 = inside radius of covering in inches and R_2 = outside radius. The numerous attributes desired in insulators are outlined. Complete tables are given showing attributes of many com. grades. Curves are given which show that the const. K does not increase directly with thickness, and that its value is not const. for all temp. differences.

C. H. E. (*C. A.*)

78. Colloid mill and the ultra-filter press. A. W. KENNEY. *Chem. Met. Eng.*, **27,** 1080–5(1922).—Two types of colloid mill are described: (1) an impact mill in which the charge of liquid and ground solid is "beaten" by a toothed wheel revolving at very high velocities (up to 12,000 r. p. m.), and (2) a friction mill in which the charge is forced axially under pressure between 2 disks rotating rapidly in opposite directions. By the use of these mills it is possible to form colloidal solns. of diverse types of solids (wood, oil shale, phosphate rock, etc.), and various tech. applications are suggested. The use of the mill also has a tendency to improve reaction conditions between 2 liquids or a liquid and a solid. In the ultra-filter press the excess of dispersion medium may be removed from the colloidal soln., forming a paste of the colloid, and yielding a clear filtrate; the operation is continuous. A bibliography is given. D. W. M. (*C. A.*)

79. Suggested methods for verification of testing machines. J. A. CAPP, *et al. Proc. Am. Soc. Testing Materials*, **22,** [1], 521–33(1922).—Definitions, methods for verifying the accuracy of machines and tolerances are given. C. C. D. (*C. A.*)

80. The "Davon" micro-telescope and supermicroscope. F. DAVIDSON. *Chem. News*, **125,** 353–5(1922).—This instrument can be utilized as a telescope or microscope. When used as the latter its working distance is greater than that with an ordinary microscope. D. E. S. (*C. A.*)

BOOKS

81. Standard Specifications for Laboratory Apparatus Adopted by the Manufacturing Chemists' Association of the United States. Part I. Graduates and Thermometers. Washington, D. C.: Mfg. Chemists' Assoc. of the U. S. 49 pp. $1.50. Reviewed in *Ind. Eng. Chem.*, **15,** 214(1923). (*C. A.*)

82. Measurement of Gas and Liquids by Orifice Meter. HENRY P. WESTCOTT AND JOHN C. DIEHL. 2nd Ed. Erie, Pa.: Metric Metal Works. 434 pp. $4.50. Reviewed in *Mech. Eng.*, **45,** 148(1923). (*C. A.*)

Kilns, Furnaces, Fuels and Combustion

83. Burning brick with electricity. ANON. *The Clayworker*, **78,** 545(1922).—Expts. have been made in western Norway near Sandnes in operating brick ovens of American manuf. by electricity. Favorable results were obtained. It is calcd. with manuf. of bricks on a large scale av. consumption of electrical power would be 1 kw. per brick which necessitates cheap power rates. J. W. HEPPLEWHITE

84. Ceramic firing in electric furnaces. E. L. SMALLEY. *Trans. Am. Electrochem. Soc.*, **42** (preprint).—Properly designed elec. furnaces are entirely dependable for ceramic firing at any temp. up to 1100°. Elec. furnace firing has been used to advantage in the manuf. of grinding wheels, china, glassware, and bifocal lenses. L. J. (*C. A.*)

Geology

85. Barytes and witherite. G. V. WILSON AND OTHERS. *Memoirs Geol. Surv.* (London), **1922.** 3rd ed.—This rept. on barytes and witherite gives characters of the barium minerals; sources of supply; commercial uses of barytes and witherites; industrial notes; detailed account of the mines and present-day mining; with descriptions of methods of treatment of the ore at various places, and means of transport. The report has graphic tables showing the total output of barium minerals in the United Kingdom since 1890; also maps of barytes and witherite areas. O. P. R. O.

86. Lac, turpentine, and rosin. (India.) ANON. *Imperial Inst. Repts.* (London), **1922.**—Shellac is a characteristic Indian product, 94 per cent of the world's supply comes from India and Burma. It is a resinous exudation produced by the lac insect, *cocus lacca*,

on various trees. The lac industry in India is unsatisfactory, and recommendations for improvements are given in this report. Turpentine and rosin have been produced in India for some time, on a small scale, only one species of pine being tapped commercially, and the turpentine from this tree is inferior to that produced in the American and French forests. It appears that better turpentine could be obtained from two other trees, *pinus excelsa* and *pinus khasya*. The industry is still in the experimental stage, but might be increased in ten years to 120,000 cwts. of turpentine, and 430,000 cwts. of rosin. O. P. R. O.

87. Strontium minerals. 1913–1919. ANON. *Imperial Mineral Resources Bur.*, **1923.**—Of the strontium minerals, celestite ($SrSO_4$), the sulphate, is the most important. It is found at some localities in sufficient quantities to be quarried as a source of strontium salts. Strontianite ($SrCO_3O$), the carbonate, also occurs abundantly in some localities, it has been worked commercially, but to a less extent than celestite. Strontium compounds are used chiefly in sugar refining and pyrotechny, sometimes as a substitute for barytes in fillers, in the manuf. of chem. reagents, medicines and glass. This report gives the world's production of strontium minerals from 1913 to 1921; with brief reviews of occurrences in the United Kingdom, Canada, India, France, Germany, Sicily and the U. S., and concludes with a bibliography on strontium minerals. O. P. R. O.

88. British Columbia clay. ANON. *Brit. Clayworker*, **31**, 360.—Samples of pottery clay taken from Lilloet, Central B. C., have been declared of the very finest quality by an expert at Portland, Oregon. He declared that samples sent to him were better than any he had seen in W. Australia. O. P. R. O.

89. Bituminous sands. (Alberta.) S. C. ELLS. *Bulletin*, Lower Athabaska and Slave River District (**1922**).—In this bulletin issued by the Natural Resources and Intelligence Branch, Canada, Mr. Ells summarizes: An extensive deposit of bituminous sand outcrops through an aggregate distance of 200 mi., centering about McMurray. 250 exposures, all of which represent portions of one continuous deposit, have been examined and measured. The outstanding features: 1. That the deposit represents the largest known occurrence of solid asphaltic material. 2. That the deposit is, as yet, totally undeveloped. 3. That at the present time practically all asphaltic materials used in Canada are imported from foreign countries. O. P. R. O.

90. A fossil resin from British Columbia. R. T. ELWORTHY. *Can. Inst. Min. and Metallurgy Bulletin*, **130**, 29(1923).—Fossil resin in coal from Coalmont, British Columbia is reported to be amber. E. gives a brief summary of the work that has been carried out on this fossil resin in the laboratories of the Mines Branch, Department of Mines, Canada; giving chem. and phys. properties of the resin, and particularly stressing its comparison with amber; and its industrial uses. O. P. R. O.

91. Canadian kaolin. ANON. *Raw Mat. Rev.*, **2**, 97(1923).—A syndicate of Vancouver business men is now planning the exploitation of large deposits of kaolin in the Cariboo district of B. C., and proposes the establishment of a fine pottery and tile industry. The clay is pure white and Govt. analyses show it to be of excellent quality. A test made at the Govt. Laboratory, Ottawa, produced a hard, white, non-absorbent tile which takes good glaze, and is pronounced equal to any imported from England. With the addition of feldspar and ball clay, which are also found in B. C., a first class china can be manufactured from Cariboo kaolin. O. P. R. O.

92. New diatomaceous earth deposit. ANON. *The Clayworker*, **79**, 155(1923).—A new deposit of diatomaceous (infusorial) earth has been opened in Maryland on the Patuxent River east of Washington. Claimed to be the best deposit in Eastern United States. J. W. H.

93. Manufacture and uses of diatomaceous earth. ANON. *Brick and Clay Record*, **62**, 414(1923).—Methods of handling deposit of diatomaceous earth at Lompoc,

Cal. is given. Area of deposit is several square miles and ranges up to 700 feet in thickness. Principal uses of diatomaceous earth are listed as compressed brick; compressed brick midway in quality of sawed brick and ordinary fire brick; ground product used as filtering material in sugar mills; light weight filler in concrete instead of rock aggregate; insulation purposes; automobile polish, etc.; nitroglycerine absorbent in some grades of dynamite. J. W. H.

94. The physical chemistry of the crystallization and magmatic differentiation of igneous rocks. V. J. H. L. VOGT. *J. Geol.*, **30,** 611–630(1922).—The influence of pressure is discussed. In deep-seated rocks the rise of the melting point of rock-forming minerals is inconsiderable. Many minerals such as olivine, monoclinic pyroxene, feldspars, spinel, magnetite, etc., can form under either low or high pressures. Melilite is found only in extrusive types (low pressure) the corresponding intrusives containing instead olivine and anorthite-bytownite. Likewise the leucite in low-pressure rocks is replaced by microcline and biotite. The formation of garnet is favored by high pressure. **VI.** *Ibid.*, 659–72.—The influence of the light volatile compds. as H_2O, CO_2, etc., is discussed. During crystn. the vol. material will be disposed of as follows: Some will escape if the pressure is high, some will be included in the minerals as inclusions, some may enter in solid soln., some may enter the crystg. minerals as H_2O in micas, the rest will remain in the magma and be concd. in the mother liquid. It is estd. that 4% indicates the max. original content of H_2O in the parent magmas. W. F. H. (*C. A.*)

95. Graphic study of igneous rock series. F. F. GROUT. *Bull. Geol. Soc. Am.*, **33,** 617–38(1922).—The nature of differentiation in 40 rock masses is shown by diagrams based on alkalies and SiO_2. Some of the conclusions are: (*a*) magmas need not be of any particular compn. in order to develop into a differential series, (*b*) the trend of differentiation is in different directions in different localities even when the magmas are similar, (*c*) nearly all alkaline rock masses have some phase near the av. nephelite syenite, (*d*) the primary magma approaches av. basalt but varies considerably. W. F. H. (*C. A.*)

96. The chemistry of the earth's crust. H. S. WASHINGTON. *Smithsonian Rept.*, **1920,** 269–319(1922).—The conditions prevailing in the earth's interior are briefly discussed, followed by a description of the general character of igneous rocks. The number of essential rock-forming minerals is small; they are silicates of Al, Fe, Mg, Ca, Na and K. The maxima and the usual range of the principal rock constituents are as follows: SiO_2, max. 99%, usual range, 75–34; Al_2O_3, 60, 20–10; Fe_2O_3, 88, 15–0.5; FeO 35, 15–0.5; MgO, 49, 25–1; CaO, 23, 15–0; Na_2O, 19, 15–0; K_2O, 18, 10–0; H_2O, 10, 2–0; TiO_2, 70, 2–0; P_2O_5, 16, 1–0; MnO, 2, 0.3–0. An estimate of the av. compn. of igneous rocks, based upon 5159 "superior" analyses is given: SiO_2 59.09, Al_2O_3 15.35, Fe_2O_3 3.08, FeO 3.80, MgO 3.49, CaO 5.08, Na_2O 3.84, K_2O 3.13, H_2O 1.14, TiO_2 1.05, P_2O_5 0.30, MnO 0.125, CO_2 0.102, ZrC_2 0.039, S 0.053, Cl 0.056, F 0.078, Cr_2O_3 0.056, V_2O_3 0.032, NiO 0.025, BaO 0.055, SrO 0.022, Li_2O 0.007%. This approximates to a granodiorite. The av. compn. of the earth's crust by elements is estd. as: O 46.43, Si 27.77, Al 8.14, Fe 5.12, Ca 3.63, Na 2.85, K 2.60, Mg 2.09, Ti 0.629, P 0.130, H 0.127, Mn 0.096, F 0.077, Cl 0.055, S 0.052, Ba 0.048, Cr 0.037, Zr 0.028, C 0.027, V 0.021, Ni 0.019, Sr 0.018, Li 0.003, Cu 0.002, Ce, etc. 0.001, Be 0.00xx, Co 0.00xx B 0.000x, Zn 0.000x, Pb 0.000xx, As 0.000xx, Cd 0.0000xx, Sn 0.0000xx, Hg 0.0000xx, Sb 0.0000xx, Mo 0.00000xx, W 0.00000xx, Bi 0.00000xx, Se 0.000000xx, Au 0.000000xx, Br 0.000000xx, Te 0.0000000xx, Pt 0.0000000xx, sum 100%. The elements are referred to two main groups in the periodic table; the petrogenic elements, abundant in igneous rocks, of low at. wt., normally occurring as chlorides, fluorides, oxides or silicates; and the metallogenic elements, rare in igneous rocks, occurring as ores of high at. wt. and forming in nature "native" metals, sulfides, arsenides, bromides, etc. The suggestion

is made that beneath a silicate crust of petrogenic elements is a zone essentially of Ni-Fe and beneath this a core of metallogenic elements. In igneous rocks and minerals the elements show a correlation of occurrence, oxides of Si, Al, K, Na tend to go together; Mg, Fe; K, Mg; Na, Fe; Na and Li, Zr, Ce, Cl, F; Mg and Pt, Cr. The idea of comagmatic regions is discussed and some are briefly described. The calcn. of rock ds. from their compn. is discussed, and the av. ds. of the continental masses and ocean floors are calcd. and shown to stand in inverse relation to their elevations. This is confirmative of the theory of isostasy. E. F. H. (*C. A.*)

BOOKS

97. High-grade clays of the eastern United States with notes on some western clays. H. RIES, W. S. BAYLEY, *et al.* U. S. Geol. Survey, *Bull.* **708,** 305 pp.(1922).—Statistics of production, imports and exports are given. Over 80 chem. analyses of the various clays are recorded, principally those from deposits in Pa., Va., Fla., Ala., Miss., Tenn., Ky., Ill., and Ark. Mineralogical compns., phys. tests and fire tests are tabulated in large numbers. The requisite qualities of high-grade clays for different purposes are specified. The deposits of kaolins or white residual clays are discussed in 114 pages, residual clays of undetd. derivation in 32, Indianaite in 15, sedimentary clays of the Coastal Plain and the Embayment area in 129, and the microscopic study of clays in 13. L. W. R. (*C. A.*)

98. Essentials for the Microscopical Determination of Rock-forming Minerals and Rocks. ALBERT JOHANNSEN. Chicago: The Univ. of Chicago Press. $2.10. Reviewed in *Eng. Mining J.-Press,* **114,** 775(1922). (*C. A.*)

99. Elements of Optical Mineralogy. An Introduction to Microscopic Petrography. N. H. WINCHELL AND A. N. WINCHELL. 2nd Ed. Revised and enlarged. Part I. Principles and Methods. New York: John Wiley & Sons, Inc. $3.50. Reviewed in *Eng. Mining J.-Press,* **114,** 1082(1922). (*C. A.*)

100. Rocks and Their Origins. GRENVILLE A. J. COLE. 2nd Ed. Cambridge: The University Press. 175 pp. 4s. Reviewed in *Nature,* **110,** 768(1922). (*C. A.*)

101. Dana's Text Book of Mineralogy. W. E. FORD. 3rd Ed. Enlarged. New York: John Wiley and Sons, Inc. 720 pp. 31s. 6d. in Australia. Reviewed in *Chem. Eng. Mining Rev.,* **15,** 137(1922). (*C. A.*)

102. Smithsonian Institution's Study of Natural Resources Applied to Pennsylvania's Resources. SAMUEL S. WYER. Washington: Smithsonian Inst. 150 pp. Reviewed in *Chem. Met. Eng.,* **28,** 130(1923). (*C. A.*)

Chemistry and Physics

103. Electrolytes' effect on plastic clay. J. D. BRUMBAUGH. *Brick and Clay Record,* **62,** 221–9(1923).—Purpose of investigation was to det. the effect, if any, of the addn. of small percentages of electrolytes to the water used in prepg. clay in such a state of workability for use in power molding machines. A history of the work of numerous investigators on similar problems is given and many references are cited. Two types of plastometers were used for obtaining an index of plasticity; namely the impact plastometer (Vicat needle as is used for obtaining the normal consistency of Port. cements) and constant pressure plastometer. Photos of each app., detailed construction data and operating procedures are given. Close parallelism of results were obtained in using each app., hence the impact plastometer was used for the expts. because of its simplicity and apparently greater accuracy. The behavior of the clay in the presence of the following electrolytes was investigated: $Ca(OH)_2$; H_2SO_4; NaCl; $BaCl_2$; $AlCl_3$; HCl; NH_4Cl; and NaOH. The clay used was a typical brick and hollow ware clay from

Stark County, Ohio and analyzed SiO_2 —63.62%; Al_2O_3 plus Fe_2O_3 —21.30%; CaO —1.40%; MgO —0.72%; H_2O —10.40%. B. concludes from the expts., electrolytes investigated may be grouped into 4 classes. (1) Electrolytes which cause the clay to become more fluid. HCl is in this group. (2) Electrolytes which first make the clay more fluid, while further additions decrease fluidity. NaCl and NaOH are of this group. (3) Electrolytes which first cause the clay to become less fluid until a certain limit is reached, when further addns. affect the clay in the opposite way. NH_4Cl; $AlCl_3$; H_2SO_4 are in this group. (4) Electrolytes which cause decrease in the fluidity. $Ca(OH)_2$ and $BaCl_2$ are members of this group. Under the microscope there seems to be three general classes of constituents in the clay. (1) Cryst. particles, (2) amorphous particles, (3) colloid particles. The first 2 classes remain constant in size regardless of varying degree of fluidity while colloid particles decrease in size with increase of fluidity. B. advances max. dispersion of class 3 is brought about by a certain concn. of anion which is const. for each electrolyte, and if this value is exceeded the clay becomes less fluid. Reverse probably due to attraction between particles being lessened owing to increase in osmotic pressure in interior of clots, thus decreasing amt. of sol present. When this action reaches a certain stage, the sol absorbs the salts, causing increase in fluidity. 1.5% NaCl causes greatest fluidity. J. W. H.

104. Clay-mud. H. CHATLEY. *Soc. of Engineers* (London), June, **1922.**—Properties of clay-mud are discussed. Clay-mud has 3 special features: (1) A granulated structure of varying degrees of fineness. (2) A semi-permanent water content, which gives it peculiar mech. properties. (3) A certain small reserve of chem. potential, which, under certain conditions, will cause it to change in various ways. Methods of observing the granular matter by means of the microscope are discussed, and C. states that the plasticity depends upon the size of the products and the proportion of colloids present. He divides the water content into 3 classes. Clay-mud containing 15% by weight of water has a tensile strength of 15 lb. per sq. in., but doubling the water content reduces the tensile strength to one-third of this amount. With 28% of water, its viscosity is about the same as a heavy grease, corresponding to a shear strain of 1 radian per 100 sec., under a shear stress of more than 100 gm. per sq. cm. It differs from heavy grease, however, in that water is extruded as the pressure is increased. It is not water-tight, and dykes allow water to percolate very slowly, but if the surface of the dyke is dry, the surface tension may arrest the flow. Conclusions conform to the common experience that water content of clay is of great importance, and they also indicate that, as with all other materials, the working stresses should be within the "elastic range." O. P. R. O.

105. Ferric oxide and alumina separated from lime. CHARRIOU. *Compt. rend.* **174,** 750–4(1922).—A sepn. of ferric oxide and alumina from lime may be accomplished in such a way as to prevent the co-pptn. of lime with the ferric oxide and alumina: A soln. contg. 0.56 gr. of calcium oxide, 2 gr. ammonium nitrate and either 0.141 gr. of ferric oxide or 0.166 gr. of alumina is treated with 2 cc. of a soln. contg. 11 mols. of ammonia per liter, the whole dried at a temp. of 150°C approx., so that all the ammonium nitrate may not be decomposed, the resulting mass washed and taken up by decantation with boiling water. To accelerate the process: Dissolve the residue insoluble after two decantations in boiling nitric acid, decomposing it at about 250°C, and taking the residue up in 50 cc. of boiling 5% ammonium nitrate soln., the ferric oxide and alumina will then remain in a dense, granular form capable of rapid washing by decantation. To overcome the difficulty of removing the adherent oxide completely from the dish during the washing; either weigh the dish beforehand and then calcine and weigh the oxides in it, or dissolve the remaining particles of the oxides in nitric acid, reprecipitate with ammonia and filter. The total volume of the washings in all the expts. in which the lime was

subsequently estd. was 500 cc.; the amounts of ammonium nitrate introduced were found to be without influence on the estn. of the calcium as oxalate. O. P. R. O.

106. Colloid chemistry, general and industrial applications. ANON. Dept. Sci. and Indus. Research, *Fourth Rept.*, **1922.**—Colloid chemistry subject matter in these reports is considered under two heads, (1) subjects mainly academic in nature, (2) subjects mainly technical. Each section has been written authoritatively, by a specialist on the subject which he treats. Under the first head are grouped: Colloids in analytical problems, cataphoresis, colloid systems in solid cryst. media, mol. attraction, membrane equilibria, disperse systems in gases, the theory of lubrication, and the application of colloid chemistry to mineralogy and petrology. Under the second head are grouped: Colloid chemistry of soap boiling, flotation processes, catalytic hydrogenation, the rôle of colloids in metal deposition, rubber, and colloid fuels. O. P. R. O.

107. Quantitative analysis of clays. O. BOUDOUARD AND J. LEFRANC. *Bull. Soc. Chim.*, **31,** 1145–52(1922).—Methods for qualitative and rational analysis are given in full with notes. O. P. R. O.

108. Barytes standardization. T. M. LOWRY. *Bull. of Indian Industries & Labour*, **22,** p. 10.—The question of standardization has recently been investigated by T. M. Lowry on behalf of the Assoc. of Br. Barytes Producers. According to the tests generally applied in the mills are those in which the foreman rubs the barytes on his thumb nail and from experience is able to grade the material, or it is rubbed on one hand and shaken on to the other, the grade being determined from the quantity shaken off. Testing with the microscope is more precise, but has limitations by reason of the small amount which can be examined. It is necessary to supplement this information by some further test, therefore Dr. Lowry has evolved a new process of testing powdered barytes in which a current of water traveling at a rate of 7 mm. per sec. is made to carry over the finer particles and leave the heavier ones behind in a graduated tube. With this app., which is simple in construction and easy to work, it is suggested that five standard grades should be recognized and adopted. The percentages of residue for these five grades are: 0.1; 1.2; 2.4; 4.8; 8.16. No satisfactory method of measuring the color of bleached barytes seems to have been devised and standardized and at present it is done entirely by arbitrary visual methods. O. P. R. O.

109. Physical properties of clay. A. S. E. ACKERMANN. *Society of Engineers, Trans.*, **1919–20–21–22.**—Physical properties of clay and the effect of water content upon their properties has been discussed by Mr. Ackermann during the last four years. He describes experiments, and shows that clays, like certain metals, have a certain measure of fluidity. When a disc resting on clay is loaded the disc sinks into the clay, the amount it descends depending on the load and on the time allowed; and when the load exceeds a certain amount, which depends upon the amount of water present, the rate and extent of penetration are considerably increased. The stress at which this occurs he calls the pressure of fluidity. His experiments have been directed toward determining the bearing power of soils, and the load that can be safely applied to them. The American Society of Civil Engineers has issued a series of reports, prepared by a special committee, to codify present practice on the bearing values of soils for foundations, and has emphasized the importance of the colloid content of clay. Most of the grains of the minerals in the clay are enveloped by colloid, but quartz grains do not, as a rule, have the colloid coating. The plasticity of the clay depends upon the amount of colloid present. To separate the colloidal from the granular material, the clay is revolved at 40,000 r. p. m. in a separator. (*Nature*, **111,** 1923.) O. P. R. O.

110. The effect of U_3O_8 upon the fusibility of Zettlitzer kaolin. O. KALLAUNER AND J. HRUDA. *Sprech.*, **55,** 523(1923).—In order to det. the effect of U_3O_8 upon Zettlitzer kaolin mixts. of varying compns. were melted in an electric furnace. The

kaolin had the following analysis: SiO_2 47.39%, Al_2O_3 37.74%, $Fe_2O_3(SiO_2)$ 0.72%, CaO 0.16%, K_2O 0.52%, ignit. loss 13.58%. The different mixts. and their softening points are given below:

Kaolin per cent	U_3O_8 per cent	Cone	Kaolin per cent	U_3O_8 per cent	Cone
100	..	35	50	50	15
99	1	34	40	60	17
95	5	33	20	80	30
90	10	32	10	90	34–35
80	20	31	..	100	35+
60	40	18	..	..	..

H. G. SCHURECHT

111. Research in Georgia clays and bauxite. ANON. *The Clayworker*, **79**, 274 (1923).—Outline of research of certain Ga. clays under a coöperative arrangement with Bureau of Mines is given and embraces whiteware clays, refractory clays, and bauxite, and vitrified face brick. J. W. H.

112. The B. t. u. chart. C. J. LOHMAN, JR. *Chem. Met. Eng.*, **27**, 1031(1922).—This chart is so constructed as to indicate directly the heat value of a fuel, given the corrected temp. rise of the calorimeter, thermometer and the % of moisture in the charge. H. L. O. (*C. A.*)

113. Purification and analysis of zirconium dioxide. F. G. JACKSON AND L. I. SHAW. *J. Am. Chem. Soc.*, **44**, 2712–14(1922).—Fusion for 1 hr. of 1 pt. oxide to 4 pts. of an equal mixt. of borax and soda ash dissolved 60–70%. When the fusion is taken up in dil. HCl the insol. residue cannot be sepd. by filtration. By pptg. the hydroxide with NH_3 the residue was held in this ppt. which could be washed free of borates and chlorides. By repeatedly pouring a slight excess of warm HCl over the ppt. the hydroxide can then be dissolved and the soln. filtered clear. Addn. of a very little H_2SO_4 then pptd. the basic sulfate which could be coagulated by heating nearly to boiling and washed free from Fe and Al. Most of the Ti is pptd. Attempts to det. Zr by volatilization of the fluoride in absence of H_2SO_4 were not successful. Twelve successive treatments with H_2F_2 reduced the residue to 2%. A. R. M. (*C. A.*)

114. A preliminary study of zirkite ore. J. G. THOMPSON. *J. Phys. Chem.*, **26**, 812-32(1922).—Zirkite (baddeleyite) ores are studied with a view to improving their refractory properties by the elimination of certain impurities. 90–95% of the SiO_2 in the raw material may be removed by heating a mixt. of the ore with just enough coke to convert the Si to the carbide, in an electric furnace, to a temp. above 2220°. With C in excess, the removal is incomplete. If the Fe be then removed by treatment with Cl or phosgene, zirconia sufficiently pure for refractory purposes might be obtained. Methods of *analysis of Zr compds.* are briefly reviewed, and a scheme for the detn. of Zr, Si, Fe, and Ti is outlined. E. F. H. (*C. A.*)

115. Surface tension in solids. G. N. ANTONOFF. *Z. physik. Chem.*, **102**, 388–92 (1922); cf. *C. A.*, **13**, 274.—A mathematical relation has been deduced for the internal pressure (P) of solids. From the values obtained for the breaking-load of rock salt crystals it is shown that $P/p^{1/3} = 1.4$ dynes/cm.^{2}, where $p = 1/d^3$ and d is the attraction between the doublets. If the attraction between the charges is not influenced appreciably by the neighboring series (of doublets), the above value for $P/p^{1/3}$ represents the surface tension in the direction of the vertical axis. If the field is sym. in all directions to the equiv. axes, then it represents the surface tension of rock salt in all 3 directions. H. J. C. (*C. A.*)

116. The full effect of variable head in viscosity measurements. F. M. LIDSTONE.

Phil. Mag., **44**, 953–5(1922).—Additional corrections in the treatment of the variable head in viscosity measurements (cf. *Ceram. Abs.*, **1** [8], 198(1922)). S. C. L. (*C. A.*)

117. Film method for measuring surface and interfacial tension. A. W. FAHRENWALD. *J. Optical Soc. Am.*, **6**, 722–33(1922).—The accuracy is discussed of each of the following methods of measuring surface tension: (1) drop wt., (2) capillary rise, (3) Jaeger, (4) vibrating jet, (5) method measuring the tension required to detach a ring, sphere, or disk from the surface of the liquid, and (6) film method. For oil-water emulsions where the surface tension depends upon the age of the surface, the film method gives the most dependable results. The instrument, which essentially consists of a liquid container, knife edge, automatic balance, pointer and scale, is carefully described. A measurement consists in lowering the knife edge into the liquid, then lowering the liquid until the edge is just about to be detached from the liquid. The liquid container is then lowered very slowly until the pointer is seen to slip back a few divisions which indicates the formation of the film. For most liquids the film lasts several seconds holding the pointer motionless at a given point on the scale. With small corrections, this method can be used for any liquid. By substituting a special frame plate for the knife edge, the tension existing at a liquid-liquid surface can be as readily measured as for the previous liquid-air surface. The instrument is standardized to read directly in dynes per cm. with the value of the surface tension of water, 72.8 dynes per cm., as the basis. The instrument is easily constructed and gives values easily reproducible to 0.1 dynes per cm. E. F. P. (*C. A.*)

118. The application of colloid chemistry to mineralogy and petrology. ALEX. SCOTT. *Brit. Assoc. Advancement Sci.*, 204–44, **1922.**—This report treats (I) of the general aspects of colloid chem. applicable to mineralogy and petrology: (1) weathering, (2) cementation, (3) adsorption, (4) determination of colloidal character or origin, (5) dendritic structure, (6) anomalous double refraction, (7) igneous rocks. (II) Rocks and minerals which either exist in colloidal form or are derived from colloidal material: (1) metals, (2) sulfur, (3) carbon, (4) silica, (5) agate, (6) bauerite, (7) chert and flint, (8) siliceous sinter, (9) alumina, (10) Mn oxides, (11) Sb oxide, (12) MgO, (13) Sn oxide, (14) Mo oxide, (15) ice, (16) sulfides, (17) silicates of Al, (18) silicates of Fe, (19) zeolites, (20) serpentine group, (21) other silicates, (22) carbonates, (23) sulfates, (24) phosphates, (25) arsenates, (26) antimonates. A very large number of references are given.
J. A. (*C. A.*)

119. The Michell viscosimeter. J. L. *Technique moderne*, **14**, 360–1(1922).—The viscosimeter consists essentially of a metal cup and a metal ball fitting very accurately in the cup. The cup is provided with 3 small projections, so that the distance between the ball and cup is accurately known (of the order of 0.01 mm.). The cup is provided with a hollow handle for the insertion of a thermometer. To carry out a detn., pour a few drops of oil in the cup, place the ball and press it firmly into the cup, reverse the position of the instrument, and note the time required for the sphere to fall. The time multiplied by the const. of the instrument gives directly the viscosity in dynes per cm.^{2} Detns. with this app. agree closely with those obtained with the Redwood viscosimeter. The Michell detns. required two hours and the Redwood nearly two days. The theory of the instrument is briefly explained. A. P.-C. (*C. A.*)

120. The flow of liquids under capillary pressure. E. K. RIDEAL. *Phil. Mag.*, **44**, 1152–9(1922).—A capillary tube of glass 1.2 m. long and 0.708 mm. av. internal diam. was mounted horizontally in a condenser tube maintained at 20°. The liquid under examn. was then drawn back and forth by suction several times to wet the wall thoroughly, and finally was forced back to a point 15 cm. from the beginning of the capillary, from which point measurements were made of the rate of penetration. The liquids examd. were isobutyl, isopropyl, allyl, Et, and Me alcs., water, water-Et alc. mixts.,

$CHCl_3$, C_6H_6, Et_2O, Me_2CO and AcOEt. The rate of advance into the capillary of a liquid under its own force is: $t = (2\eta/\gamma^r)x^2 - (\delta r^2/\gamma\eta)\log x$ in which t is the time, η the viscosity, γ the surface tension, x the distance traversed, and δ the d. of the liquid. For relatively large capillaries the *penetration coeff.* is $\sqrt{\gamma r/2\eta}$. The exptl. detn. of the coeff. is shown to agree with calcn. In the case of mixts. the dynamic surface tension and not the static values are probably the governing factors. The reciprocal of the penetration coeff. is proportional to the sq. root of the period of mol. relaxation as defined by Maxwell, and by analogy with reactions in the solid state is probably important in reactions taking place in liquid media. S. C. L. (*C. A.*)

121. Films. The spreading of liquids and the spreading coefficient. W. D. HARKINS AND A. FELDMAN. *J. Am. Chem. Soc.*, **44**, 2665–85(1922).—A theoretical paper in which it is shown that the criterion of spreading or non-spreading of liquids may be presented in a very simple way in terms of a simple and thermodynamically detd. coeff., termed the *spreading coeff.* This coeff. is defined as $S = Wa - Wc$, where Wa is the work of the surface adhesion and Wc the work of the surface cohesion of the liquid. A positive value of S corresponds to spreading, a negative value to non-spreading. Expts. were made with org. liquids on the surface of water and *vice versa*, and with org. liquids and H_2O on the surface of Hg. Almost all org. liquids spread on H_2O, while H_2O spreads on very few org. liquids. The non-spreading of org. liquids on H_2O is brought about by the presence in the org. mol. of Cl, Br, I, =S, =CS, or by Ph groups. Monomol. films are produced on H_2O only when the spreading coeff. has a relatively high value. These high values seem to occur only when the spreading substance has a polar group in its mols. H. J. C. (*C. A.*)

122. A molybdenum resistance vacuum furnace. P. FLEURY. *Compt. rend.*, **175**, 880–2(1922).—Molybdenum wire is wound on an alundum core and surrounded by alundum. This is sealed in a vacuum iron case. The furnace can be used to 1700°. A. H. D. (*C. A.*)

123. Identity of amorphous and crystalline silicon. W. MANCHOT. *Z. anorg. allgem. Chem.*, **124**, 333–4(1922); cf. *Ceram. Abs.*, **1** [8], 206(1922).—X-ray examn. of the 2 forms of amorphous Si by Debye has shown them to be cryst. and to have the same diamond-like structure as the ordinary form. M.'s assumption that the differences in chem. properties shown by these forms were due solely to greater ratio of surface to mass is thus firmly established. The following additional observation on the chem. behavior of these pseudo-amorphous varieties is appended. When the black variety, obtained by quenching its soln. in metals, is rubbed with PbO_2, it flames vigorously even in the cold while the yellow-brown variety obtained by action of H_2F_2 on the black variety explodes violently when rubbed with PbO_2. A. R. M. (*C. A.*)

124. Simple apparatus for comparing the thermal conductivity of metals and very thin specimens of poor conductors. M. S. VAN DUSEN. *J. Optical Soc. Am.*, **6**, 739–43 (1922).—The method consists in comparing the temp. gradients in two materials placed in series, the rate of flow in each being the same. App. for this investigation is fully described and data are given for contact material including dry boundary, contact water, mineral oil, and various thicknesses of paper and mica, between two horizontal cylinders. The thermal conds. of Zn, Al, Sn, Pb, and Navy brass detd. in this app. check previous values in every case within 5%. E. F. P. (*C. A.*)

125. A problem in viscosity: The thickness of liquid films formed on solid surfaces under dynamic conditions. RESEARCH STAFF OF THE GENERAL ELEC. CO., LONDON. (Work conducted by F. S. GOUCHER AND H. WARD.) *Phil. Mag.*, **44**, 1002–14(1922).—The detn. of the thickness of the liquid layer coating a solid body drawn out of a liquid is discussed theoretically and practically. It is shown that if the solid is a flat slab of infinite width, the forces detg. the thickness are those of gravity (g) and viscosity (η)

and the relation between thickness (t), density (ρ), and the velocity of drawing v_0 is: $t^2 = 2v_0\eta/\rho\ g$. If the solid is a fine wire of radius r, surface tension is dominant and gravity negligible. If γ is the surface tension, the relation must be of the form: $t/r = f(\eta v/\gamma)$. It is found empirically that $f(\eta v/\gamma)$ is of the form: $4.8\ \eta v/\gamma$ in c. g. s. units. These results apply to suspensions if, (1) the diam. of the suspended particles is not greater than t, (2) if the effect of the particles in increasing η is taken into account. There is no evidence of any special cohesion between solids and liquids wetted by them other than that which prevents slipping at the interface. S. C. L. (*C. A.*)

126. Colloidal systems in solid crystalline media. CECIL H. DESCH. *Brit. Assoc. Advancement of Sci.*, 4th Report, 33–40, **1922.**—The first part reviews some of our present knowledge on the colloidal dispersion of some of the constituents of *steel* and *alloys*, and even the *iso-colloidism of pure metals*. Since "the dimensions of the grains are considerably above the limits which are usually assigned to the colloidal state, it is unlikely that any advantage would be gained by including this aspect of the structure of metals under the heading of colloid chemistry." [This is erroneous, because the effects of subdivision transcend the limits mentioned. Besides, visible grains, metals and alloys contain in addition truly colloidal particles. J. A.] A brief very incomplete section on the "*Coloring Matters in Crystalline Minerals*," is also included.

J. A. (*C. A.*)

127. A small high intensity mercury arc in quartz glass. L. J. BUTTOLPH. *J. Optical Soc. Am.*, **6,** 1066–71(1922).—This illuminator is a self-contained unit furnished to operate on 110 v. either a. c. or d. c. The effective light source has an area of $^1/_4'' \times 1^3/_4''$ and is provided with a removable mica filter for absorption of extreme ultra-violet, an adjustable slit, and a light-tight holder for filters. By use of Cornings G555P and G34 glasses λ 5461 may be isolated; or by use of Noviol A and G 585 glasses λ 4359 may be obtained as monochromatic light sources. By use of Wratten filters other lines may be isolated. The instrument has two operating conditions. With enough resistance in series it is a low pressure arc giving only the strongest spectrum lines, and if operated at highest intensity it changes to a high pressure arc giving a continuous spectrum with additional Hg lines. D. E. S. (*C. A.*)

BOOKS

128. Tested Methods of Non-Ferrous Metallurgical Analysis. SEYMOUR PILE AND REGINAL JOHNSTON. London: H. F. and G. Witherby. 128 pp. 7s. 6d. Reviewed in *Chem. News*, **125,** 208(1922); *Chem. Trade J.*, **71,** 396(1922) and *Chem. Age* (London), **7,** 492(1922). (*C. A.*)

129. The Chemical Analysis of Rocks. H. S. WASHINGTON. 3rd Ed. Revised and enlarged. New York: John Wiley & Sons, Inc. 271 pp. $2.50 (12s. 6d.) (*C. A.*)

130. Handbook of Chemical Engineering. 2 Vols. Edited by Donald M. Liddell. New York: McGraw Hill Book Co. $8. Reviewed in *Chem. Met. Eng.*, **27,** 1184 (1922). (*C. A.*)

131. Textbook of Chemical Engineering. EDWARD HART. 2nd Ed. revised. Easton, Pa.: Chemical Publishing Co. 241 pp. $4. Reviewed in *Chem. Met. Eng.*, **27,** 757(1922). (*C. A.*)

General

132. Largest brick plant in the world. ADDIE M. WALLACE. *The Clayworker*, **79,** 146–49(1923).—Description and photos of Simons Brick Co. various plants at Los Angeles, Calif. and vicinity. J. W. H.

133. Common Brick Manufacturers' Association meeting. ANON. *The Clay-*

worker, **79,** 140–42; 170(1923).—A review of C. B. M. A. convention held in Cleveland, Ohio, Feb. 5, 6 and 7. J. W. H.

134. National Brick Manufacturers' Association convention. ANON. *The Clayworker*, **79,** 125–38, 237–73, 288, 290, 292(1923).—Verbatim report of 37th annual convention of N. B. M. A. held in Cleveland, Ohio, Feb. 7, 8 and 9. J. W. H.

135. Hollow Building Tile Association convention. ANON. *The Clayworker*, **79,** 152–3(1923).—A review of the 5th annual meeting of H. B. T. A. held in Chicago, Ill., Jan. 25 and 26. J. W. H.

136. Silver jubilee convention of The American Ceramic Society. ANON. *Brick and Clay Record*, **62,** 319–22, 352–4, 356–8(1923).—A report of convention activities and the salient points of papers presented in the various divisional meetings. J. W. H.

137. Common Brick Manufacturers' Association convention. ANON. *Brick and Clay Record*, **62,** 310–5(1923).—Report of annual convention at Cleveland, Ohio, Feb. 5–7. J. W. H.

138. National Paving Brick Manufacturers' Association convention. ANON. *The Clayworker*, **78,** 559(1922).—A review of the annual meeting held Dec. 12 and 13, at Cleveland, Ohio. J. W. H.

139. Silver jubilee convention of American Ceramic Society. ANON. *The Clayworker*, **79,** 150–1, 172, 181–2, 184.—A review of the 25th annual convention held in Pittsburgh, Pa., Feb. 12–16. J. W. H.

140. Annual meeting of New Jersey Clay Workers' Association and Eastern Section of American Ceramic Society. L. W. ALLISON. *Brick and Clay Record*, **62,** 48(1923).—A report of the annual meeting held at Rutgers College which includes salient points of papers delivered in symposiums on casting of ceramic wares and oil burning. J. W. H.

141. Annual convention of Hollow Building Tile Association. ANON. *Brick and Clay Record*, **62,** 210–3(1923).—A report of H. B. T. A. convention at Drake Hotel, Chicago, Ill., Jan. 25 and 26, 1923. J. W. H.

142. Canadian convention. ANON. *Brick and Clay Record*, **62,** 218–9(1923).—A report of joint convention of Canadian National Clay Producers' Association and The Western Ontario Clay Workers' Association in Hamilton, Ontario, Jan. 23–25. Plant problems constituted the major part of the program. J. W. H.

143. American Face Brick Association convention. ANON. *Brick and Clay Record*, **61,** 858–62(1922).—Report of convention at West Baden Springs Hotel, West Baden, Ind., Dec. 5–7, 1922. J. W. H.

144. Cleveland, a clay center. ANON. *The Clayworker*, **79,** 23–34(1923).—A description of 18 clay products plants located in Cleveland which produce common, face and paving brick, sewer pipe and hollow tile. Also unusual features in equipment and methods of operation. J. W. H.

145. American Face Brick Association convention. ANON. *The Clayworker*, **78,** 546–51(1922).—A review of the annual meeting of the A. F. B. A. at West Baden. J. W. H.

146. A refractory survey (proposed). ANON. *The Clayworker*, **78,** 568(1922).—A contemplated survey sponsored by the Refractories Manufacturers' Association. The purpose of which is to uncover a mass of information with regard to furnace conditions as in actual service. Progress reports will be made as information is gathered. J. W. H.

147. Research bureau laboratory, Standard Steel Car Co. RICHARD RIMBACH. *Chem. Met. Eng.*, **28,** 110(1923). E. J. C. (*C. A.*)

148. The electric steam generator. HORACE DREVER. *J. Ind. Eng. Chem.*, **14,** 923–5(1922).—The elec. generation of steam by passing a. c. (usually high tension)

directly through the water is economical for utilization of off-peak power and is generally profitable in localities where hydroelectric power is abundant but fuel is expensive. An elec. steam generator of 1000 kw. capacity is equivalent to a boiler of 100 h. p. (cf. also *Elec. World*, **80**, 1211–2(1922)). L. J. (*C. A.*)

149. Some recent developments of powdered-coal firing. J. S. ATKINSON. *Iron Coal Trades Rev.*, **105**, 924–7(1922).—The prepn. and utilization of powdered coal are discussed in connection with its drying, pulverizing, burning, and the removal of the ash. The turbo-pulverizer is especially recommended (cf. *C. A.*, **16**, 1001). Under usual working conditions an efficiency on boiler, superheater and economizer of 86% can be obtained and maintained with pulverized coal. J. L. W. (*C. A.*)

150. Gasification of Ohio coals. D. J. DEMOREST. *Chem. Met. Eng.*, **27**, 1172–5, 1221–4(1922).—The suitability of Ohio coals for gas manuf. was studied in a vertical retort of commercial size. The methods of operation of the retort and various methods of control analyses are also given. The data are tabulated and discussed. Coke suitable for domestic heating but inferior for metallurgy was obtained. A little less tar and about the same amts. of NH_3 were produced as from standard gas coal. About the same vol. of gas as from standard gas coal but with lower calorific value was obtained. W. A. M. (*C. A.*)

151. The commercial application of electroösmosis. J. H. FRYDLENDER. *Rev. prod. chim.*, **25**, 721–30(1922).—A review of the theoretical principles of electroösmosis and electrophoresis and of their application to drying peat, purifying and molding clay and kaolin, prepn. of colloidal SiO_2, purification of tan liquors, tanning of hides, sterilizing and improving foodstuffs, preservation of green fodder, purification of glues and gelatins, prepn. of pure serums, extn. of sugar from molasses, decolorizing sugar juices, purification and elimination of alkaloids, purification of crude glycerol, prepn. of $Al(OH)_3$, and dehydration of coloring matters. The article is based very largely on the patent literature. A. P.-C. (*C. A.*)

152. Powdered coal as fuel in steam plants. H. KREISINGER AND J. BLIZARD. *Proc. Eng. Soc. Western Penn.*, **38**, 169–200(1922).—Three groups of tests using powd. coal on a 3-pass Edge Moor boiler equipped with a "Lopulco" furnace and the results of a 9-day test on 2 Stirling boilers are reported. Overall thermal efficiencies of from 80% to over 90% were obtained. Drawings of furnace settings, the burner for powd. coal, the isothermal lines in operation of a furnace burning powd. coal, together with graphs showing the % CO_2, excess air, temp. of flue gas and uniformity of furnace conditions with variable load are given. Prevention of the destruction of furnace lining by high temp., easy removal of ash, effect of a water screen in the furnace and recent improvements in furnace design are discussed. Much valuable information comparing stoker fired furnaces with those burning powd. coal is contained in the extended discussion which follows the article. W. W. H. (*C. A.*)

153. The protection of brass weights. J. J. MANLY. *Phil. Mag.*, **44**, 948–50 (1922).—A modification of a method first used by Faraday to protect Fe from rust, is applied to brass wts. The wts. are tooled to remove tarnish, polished, heated in a semi-luminous gas flame until nearly red hot and then plunged into boiled linseed oil and left to cool. After removal and washing with turpentine and polishing with old linen, the wts. are adjusted, standardized and put into use. Modern coal-gas contains too much S for direct heating, and it was found necessary to use a vitreosil crucible with lid or a muffle. After cleansing and polishing each wt. is covered with a thin layer of linseed oil and then placed on a 3-point porcelain support in the crucible or muffle just above a layer of asbestos. Heat is applied until a golden tint is observed, when the heating is ended and after cooling an even coating is obtained which weighs about 0.05 mg. per sq. cm. of surface. S. C. L. (*C. A.*)

154. Commercial electro-thermic processes. II. BRUNO WAESER. *Chem.-Ztg.*, **46,** 928–30(1922); cf. *Ceram. Abs.*, **2** [2], 19(1923).—The methods of *fusing silica* and the use of elec. furnaces in *melting and mfg. Fe and Fe alloys* are briefly surveyed. Among the alloys of Fe are included those with Si, Mn, Al and Ti. **III.** *Ibid.*, 947–8.—The *manuf. of ferro-Cr, ferro-Ni and ferro-Mo, CaC_2, Al, P and CS_2* are briefly reviewed. Numerous places are mentioned at which the processes are being carried out. **IV.** *Ibid.*, 970–2.—Brief review of *Zn melting and refining, manuf. of cement and steel;* use of elec. heating in *coal distn., fixation of N_2* in the arc; and elec. *steam generation.*

M. K. (*C. A.*)

155. The control of works operations by scientific instruments. LEONARD LEVY. *Chem. Age* (London), **7,** 734–7(1922).—A brief outline of the application to works control of the X-ray tube, refractometers, spectrometers, viscosimeters, pyrometers and the like. W. H. B. (*C. A.*)

156. Earning power of research as demonstrated by the experience of the American Rolling Mill Company. D. M. STRICKLAND. *Ind. Eng. Chem.*, **15,** 78–9(1923).—By adequate support of a no. of research problems, it is contended that at least 1 problem will be successfully solved and repay the entire research expense. C. C. D. (*C. A.*)

BOOKS

157. Filtration. T. ROLAND WOLLASTON. London: Sir Isaac Pitman & Sons, Ltd. 102 pp. 2s. 6d. Reviewed in *Chem. News*, **125,** 270(1922). (*C. A.*)

158. Discoveries of the Twentieth Century. EDWARD CRESSY. London: Routledge & Sons, Ltd. 12s. 6d. Reviewed in *Chem. Trade J.*, **71,** 770(1922). (*C. A.*)

159. The Wonder Book of Chemistry. JEAN H. FABRE. Translated from the French by Florence C. Bicknell. New York: The Century Co. 385 pp. $2.50. Reviewed in *Am. J. Pharmacy*, **95,** 65(1923). (*C. A.*)

160. Scientists' Reference Book and Diary, 1923. Manchester: Jas. Woolley Sons & Co., Ltd. 174 pp. 3s. 6d. Reviewed in *Pharm. J.*, **109,** 563(1922). (*C. A.*)

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Vol. 2 May, 1923 No. 5

EDITORIAL

EQUIPMENT MANUFACTURERS AND MATERIAL PRODUCERS ARE RESEARCH ENGINEERS

Salesmen of ceramic materials and equipment have been styled ambassadors. They are representatives from one concern sent to another in the interest of the welfare of both. They are selling goods, hence cultivating a market for them, but the highest type of the present day salesman does more than that; he gives honest service.

The factory or house which the salesman represents has studied the requirements of the most efficient plant control and manufacturing, has devised machines, instruments, and methods, and has trained its sales representatives to demonstrate them.

The goods they sell were devised to meet a requirement rather than a demand; the demand is created by demonstration.

The inventing of a machine, device or instrument and the preparation of a material is based on a series of technical researches and the pyramiding of experiences. No machine or apparatus will find a continued sale that does not contain the most serviceable material known and which has not the proportion and design which will most effectively meet the requirements of ceramic manufacturing. The selection of the proper materials, proportions and designs requires a search through the world's accumulation of knowledge, an ability to select that which applies, and then to fabricate from the knowledge thus selected and marshalled an apparatus that will serve a given purpose.

The successful and progressive equipment manufacturer must be a research engineer with a genius for seeing the utilitarian possibilities of the bits of abstract knowledge discovered by the fundamental scientists, and he must have the ability to devise and to build them into a serviceable apparatus. The manufacturers of ceramic equipment and devices and those who find and prepare materials for use in the manufacture of ceramic wares are ceramic engineers who serve the ceramic industries just as effectively as do the ceramic engineers who are directly employed in manufacturing ceramic wares.

The fundamental scientists analyze for the purpose of finding the ultimate properties of substances singly and in combination. They are not concerned with the utilitarian possibilities of the facts they disclose. They are analysts.

Inventors are those who see the utilitarian possibilities of the facts which are disclosed by the scientist and who have the ability to create a process or equipment embodying the fundamental facts of the scientists. Synthesis is the opposite of analysis. Analysis is the taking apart and synthesis is the putting together. Inventors are our synthetic engineers.

Inventing and building are but one of the problems of the equipment manufacturer. The equipment must be installed and operated and the material must be used as a constituent in a mix. Here is where the sales ambassadors serve both the producer and the user of ceramic materials and equipment.

There are patented kilns, dryers, gas producers, furnaces, leers, pyrometers, etc., which have proven to be of economic value to ceramic manufacturers but it could hardly be expected that any one device will be equally successful under all conditions. It is rare indeed that a device does not have to be adapted to a condition. This is where the service of the sales ambassadors comes in.

The equipment manufacturer is seeking a market for that in which he has invested a large amount of time and money in construction research, and the ceramic manufacturer is seeking equipment, processes and materials that will enable him to manufacture at less cost with no deterioration in quality of ware. The equipment and material producer employs sales demonstrators and sends them to the ceramic manufacturers. He pays for space in journals wherein he aims to tell the ceramic manufacturer the advantage of using his equipment or material. This he does for his own profit but if there ever was a group of manufacturers of whom it can truly be said that "he profits most who serves best" it is the manufacturers of equipment and the producers of raw materials.

This editorial is an argument for a larger use by ceramic manufacturers of the services of the producers of equipment and materials, to study with them in an intimate fashion the problems of ceramic production, for thus

will both the producer and user of equipment and materials discover that which will be the most economical.

For legal problems a lawyer is employed; for medical problems a doctor is employed, for power problems a power engineer is employed; for chemical problems a chemist is employed. Such experts as these are paid salaries or fees. Why is it not logical to employ equipment engineers on equipment problems? Is it because they do not charge a fee unless their equipment is purchased? A study of the catalogs and advertisements of equipment producers will be without cost but it will be productive of new ideas and facts which can be profitably applied. A letter will bring a consulting service without further cost.

The equipment and material producers are ceramic engineers worthy of hire at their own terms.

PAPERS AND DISCUSSIONS

ZIRCONIA IN SHEET IRON ENAMELS[1]

By W. F. Wenning

Zirconia means zirconium oxide. Zirconium, as far as we know, is one of the elements that composes the earth. Its *chemical and physical* properties make it a desirable ingredient for ceramic products. Investigation and research have yet left a large field incomplete *for the unlimited use of zirconia* in ceramic products.

The largest deposits of zirconia have been found in South America. The deposits in this region are so vast it would compensate further research in its applicability to ceramic products.

The difficulty of transporting the ore from the field to the sea port has really made it one of the rare earth elements. From ten to fifteen pairs of oxen are required in carrying a single ton of ore over the almost inaccessible mountain road. Baddeleyite is the chief mineral of this ore whose composition varies as follows: Zirconium oxide, 75 to 94%; titanium oxide, 1 to 3%; iron oxide, 2 to 4%; silica, 10 to 20%; alumina, 1 to 4%.

This material, despite being one of the hardest substances known is pulverized to a very fine powder. This powder has a light yellowish brown appearance and can be used in enamels in this form. Most of the iron can be removed from the ore by prolonged acid digestion. This *almost iron free material* has the appearance of a light gray powder, but its composition is not otherwise changed. After this first step in refining it may be used in enamels where iron is an undesirable constituent. White chemically pure zirconia is the ultimate refined product. It may be used to obtain the desirable properties of zirconia in enamels, but its cost prohibits its commercial use. Similar properties in enamels have been effected by the use of the so-called white technical amorphous zirconia.

The composition of white technical zirconia depends on its process of manufacturing. Most specimens retain the titanium oxide, a small percentage of silica and traces of iron; while others contain small percentages of sodium and potassium oxides.

Brown and gray zirconia were adapted, respectively, to ground coat and gray mottled enamel. The smelting process of these enamels makes it possible to thoroughly dissolve the zirconia; while for white enamels it was found that white zirconia was the only form suitable as a batch ingredient. The amorphous property of the white powder caused it to be uniformly distributed if not dissolved by the smelting process.

The brown zirconia used in ground coat enamels exhibited no ill effect because of its iron content, while the high percentage of zirconium oxide in the brown zirconia displayed *its* properties sufficiently. Zirconia having

[1] Presented before the Enamel Division, Pittsburgh meeting, February, 1923.

properties similar to alumina and silica was used in place of these ingredients in ordinary ground coat enamels. A replacement up to ten per cent by zirconia in the batch changes the working property of the enamels very little, while high replacements rendered the enamel very viscous and difficult to smelt down. Enamels containing up to ten per cent zirconia were more elastic and tested to be stronger enamels with better adhesion to the steel.

Without changing the original batch formula, but adding from one to five per cent zirconia to the mill formula, the fish-scaling tendency was reduced and in one enamel crazing was overcome. Pinholes in ground coats which show up through the white cover coats are caused chiefly by impurities in sheet iron. A ground coat that ordinarily was giving good results was changed by the addition of two per cent brown zirconia to the mill formula. The pinhole defects were markedly reduced; gases or other impurities were allowed to escape or were absorbed by the zirconia.

The gray almost iron free zirconia was used and tested in gray mottled ware enamels because its low iron content did not discolor the enamel. Zirconia was also partially substituted for alumina and silica. Stronger and lighter colored enamels which showed less fish scaling were produced. Substitutions were also made for bone ash and antimony. The color through these substitutions was little affected. The enamel in which zirconia replaced the bone ash was changed after its application on the metal to a slightly darker color and the blister and rust spot tendency of bone ash enamels was eliminated. Substitutions for antimony made no change in color, but the fusibility or melting point of this enamel was slightly increased. High zirconia substitutions for silica and alumina in the gray enamel while making the color lighter had a slight tendency to produce a sunken mottle. Although the enamel so produced was not quite so smooth as the unchanged enamel its resistance to acids and heat and mechanical shock was markedly improved.

With all its other virtues, zirconia has its chief virtue in its opacifying property. This property, however, was not directly obtainable from previously mentioned brown and gray zirconia. The white amorphous powder alone was the one which could be matched against other opacifying ingredients. It was used as a batch ingredient to replace silica, alumina, zinc oxide, antimony oxide, tin oxide, and phosphates. The enamels so changed were whiter and more opaque. These same enamels when used with tin oxide in the mill formula were also whiter and more opaque and more glossy than the original enamels. Enamels in which zirconia was used in the mill formula were whiter and their opacity approached very closely to those in which tin oxide was used in the mill formula.

Zirconia used in mill formulae of low fluoride enamels produced exceptionally good opacity and whiteness. Such enamels are more acid resistant because of their low fluoride content and the added zirconium oxide.

In addition to the opacifying property of zirconia it may be summarized that enamels containing zirconia are more resistant to mechanical and thermal shock; they are more acid resistant and the zirconia in these enamels is not affected by reducing furnace heat.

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PRICING AND COSTING GRADED PRODUCT[1]

BY NORMAN E. WEBSTER

In many kinds of manufacturing, mining, agriculture and other industries, the product from the same or identical operations is of varying degrees of excellence as measured by standard specifications. The differences between the grades may be in quality, in size, or in some other condition. Manufactured goods and agricultural products are often graded for quality; coal and other mining products for size. In each industry experience shows the proportions of each grade that are ordinarily obtained. Fortunately, it is usually possible, as it is always desirable, to obtain a market for the entire output, and to have the demand so balanced that the output of each grade can be regularly sold in about the proportions in which it is ordinarily produced.

In these cases the producer is confronted with the problems of price-fixing, in so far as that is within his power, and of ascertaining the costs of production as a basis for the fixing of prices or for comparison with the prices which are obtainable. The purpose of this discussion is to consider the problem of costing graded product, and to show its relation to the problem of pricing the different grades.

Two other classes of salable material should not be confused with graded product; *viz.*, scrap and by-products. Scrap is the salvaged material resulting from manufacturing processes which cannot be fabricated into the regular product without again being put through one or more of the processes to which the raw material is subjected, and when it has a market value, the net amount received for it should be deducted from the expenditure for the raw material used in the product. By-products are side lines of production in which are used residual materials resulting from the production of the principal lines. These residuals usually require further work to make them salable, and the expenditures therefor should be deducted from the selling prices to obtain the net proceeds, which amounts should be deducted from the departmental costs for materials, labor, and expenses of the regular product.

Graded product differs from scrap and from by-products in that all of

[1] Read and discussed before the Glass Division, Pittsburgh meeting, February, 1923.

it has been the object of all the productive operations. It is all regular product, though the several classes have different values, varying according to the demand for each.

In pricing different grades of product, consideration should be given to the questions of demand and of the effect which the price on one grade will have on the demand and the obtainable price for the others. Where the product is a necessity for which there is a universal demand, the prices should be so adjusted as to create demands for each class in quantities approximately equal to the quantities produced, and so that the average selling price for all classes will give a proper rate of net profit over the average production costs.

But there are other considerations to be taken into account in fixing selling prices on graded product of articles which are not necessities and for which there is not a universal demand. Manufacturers' seconds in many lines require this careful attention. The bulk of the output is usually of the first or standard grade, and in order not to unsettle the market conditions on this grade, or to cheapen the value of a trade name, it may be better policy to scrap all product not of the standard grade, or to offer the seconds at prices which will not sell all of them. In such cases, the standard grade should be priced so as to yield a proper rate of profit on the expenditure for all the product of both grades. Then if it is advisable to scrap the seconds, or to salvage the material in them, the entire line will still show the desired profit, while if a part or all of the seconds are sold, the amount and rate of profit will be correspondingly increased.

In addition to these questions of policy involved in the pricing of graded product, the costing of the different classes raises about as many accounting questions, the solution of which is necessary in order that the costs may be compared with the selling prices and thereby help to solve the questions of policy involved in pricing. Commonplace as it may sound, it seems necessary to reiterate that pricing and costing should go hand in hand.

Three methods of costing may be considered: First, that the cost is the same for each unit in all classes of the product, based on the theory that the same amounts for material and labor have been expended on each. Secondly, that the cost of each unit of the seconds is only the value of the scrap material therein, and that the remaining expenditure should be absorbed in the costs of the firsts, based on the theory that the expenditures were all made to obtain the firsts. Thirdly, that the costs of the units in each class include unequal parts of the expenditures, based on the theory that quality as well as quantity should be considered in measuring or reckoning the product, and that, therefore, units of identical dimensions or weights, but of unequal qualities, have not received equal benefit from the expenditures made for their processing.

For the purpose of considering the soundness of each of these methods of costing the product, the following illustration may be taken: Assume that a mill run of some article consists of 100 units, that 60 are firsts because they fully conform to inspection specifications, that 30 are salable seconds, and that 10 are unmarketable rejections. Assume also that the expenditures for this quantity are $20.00 for material and $80.00 for labor and overheads, that the realizable selling prices are $2.00 each for the firsts, and $1.00 each for the seconds, and that there is a salvage value of 10 cents each in the material in the 10 rejections. The account for this run exclusive of selling and general expenses will then be as follows:

Sales:			
Firsts, 60 units @ $2.00		$120.00	
Seconds, 30 units @ $1.00		30.00	
			$150.00
Cost of Sales:			
Material for 100 units:			
100 units @ $0.20	$20.00		
Less scrap:			
10 units @ $0.10	1.00		
		19.00	
Labor and Overheads		80.00	
			99.00
Manufacturing Profit (51.5% on Cost)			$51.00

The following gives a comparison of the results per unit by each of the first two methods of costing the product, losses being indicated by an asterisk after the amount or percentage:

Method	Grade	Price each	Cost each	Profit each	Total profit	% Profit on cost
First,	60-1sts	$2.00	1.10	0.90	54 00	81.8
	30-2nds	1.00	1.10	0.10*	3.00*	9.1*
Second,	60-1sts	2.00	1.60	0.40	24.00	25
	30-2nds	1.00	0.10	0.90	27.00	900

In examining the results of the first method, we should remember that the aim is to produce the greatest possible proportion of units of the first or standard grade, and that business policy might make it inadvisable to market any seconds. In that case, the total expenditures less the salvage value of the materials in the 30 seconds and the 10 rejections, or a net amount of $96.00, would be charged to the production of 60 firsts, making the cost $1.60 each, but although the comparative table shows that, by the first method of costing, there is a profit on the firsts of 81.8% on cost, the total profit of $51.00 can only be secured by selling all of the seconds at a loss of 9.1% on cost. Profits are not made out of losses in that way, and the first method is therefore unsound in economics.

The second method results in showing a profit on the firsts of 25% on cost, and this is not dependent upon the sale of the seconds. By this method, the cost of the seconds is computed at only the salvage value of the material in them, and yet the price obtained is largely in excess of the salvage value. The reason is that in addition to the material, the seconds possess value as a result of the labor and overheads which have been expended. Having received a portion of the benefit, they should be charged with a proper proportion of the expenditures and not be relieved of them as are the rejections which have not been so benefited.

The error in the first method is in not distinguishing between expenditures and costs. Expenditures are an element of costs of which the other factor is product. By assuming that expenditures are identical with costs, the former would have to be permanently allocated to each article as the material was set apart for it and the labor was applied to it, and this would result in making each of the ten rejections cost the same as each of the firsts and seconds. The error in the second method is in not recognizing that in the production processes the seconds received some of the benefits of the expenditures for labor and overheads, though in less degree than the firsts.

The third method is based on the varying degrees of benefit applied to the different grades of the product. What these are cannot be ascertained during the manufacturing processes. They are not subject to count, or to measurement by the yard stick, peck measure or scales. But they are measurable in another way which is by the prices at which the different grades can be sold. These prices provide a basis for converting the quantities of all grades into some common standard which, for convenience, should be that of the first or standard grade. Each second is equal in quantity to that fraction of a first which is represented by the price of the second divided by the price of the first.

Applying this method to the illustration already used, the result is as follows:

Method	Grade	Price each	Cost each	Profit each	Total profit	% Profit on cost
Third,	60-1sts	$2.00	1.32	0.68	40.80	51.5
	30-2nds	1.00	0.66	0.34	10.20	51.5

This method, therefore, shows 51.5% profit on both the firsts and the seconds; that is, the average rate for the entire mill run as shown in the original statement of the transaction. If now, after thus costing the two grades of product, it is found that not all the seconds can be sold at the proposed price, or if it is considered inadvisable to market them all, then the average rate of profit will be reduced pro rata, depending upon the number of the seconds that are scrapped. Thus, instead of 51.5% profit when all seconds are sold, the rate will be 42.9% if ten seconds are scrapped, 34.2% if twenty seconds are scrapped, and 25% if none of the seconds

are sold, this being the lowest rate of profit that the run can show if all the firsts are sold at the regular price of $2.00.

Properly computed costs on graded product are helpful to the executive in determining manufacturing and sales policies, while costs computed on erroneous bases of distribution may lead to the unsettling of market conditions if not to more serious consequences.

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DISCUSSION

CHAIRMAN HOSTETTER:—As one gets into production and realizes the ramification of expenditures and costs it seems hopeless at times to know whether a new process is a success or not.

E. W. WASHBURN:—I would like to ask a question in regard to a point which the paper did not touch upon, that is the cost of process development. Are there any principles which are worked out for handling this cost, as to the number of years it is spread over and so forth?

N. E. WEBSTER:—You mean the development of a process prior to the stage where it produces a marketable product?

E. W. WASHBURN:—Yes.

N. E. WEBSTER:—That is one of the many phases of cost accounting which were not even touched upon in the paper on costing graded product. Development work may be done for the purpose of producing a patentable mechanism or process or formula. It may be done for the purpose of devising equipment or methods which will not be patentable but which through secrecy or otherwise can be temporarily reserved for the benefit of those who developed it. The development work may all be prior in time to the use of the resulting process, or it may be carried on for a considerable time and the results may be utilized in the current productive operations.

Every live progressive organization will try to improve methods and to obtain immediate benefit from the improvements made. The expenditures for the ordinary development work of that kind may not be susceptible of segregation from the purely operating expenses, and inasmuch as they are usually not large in proportion, they should be included in the current costs. Each period benefits from the results of the expenditures made during earlier periods and pays for such benefits by its contributions toward the future.

However, if the development work is not the ordinary improvements but the process is to be completely developed before it is used in production, the expenditures should be excluded from the current costs and should be treated as deferred charges, which may at once be written off against

the surplus or may be carried on the balance sheet as suspense items. Later when the development work is completed and the process is shown to be successful, the suspense items may be transferred to the capital assets if the process is secured by patent protection or they may be treated as deferred charges for absorption in the subsequent costs during a stated period which should be a conservative estimate of the time during which benefits will be derived from the process.

E. W. WASHBURN:—Are there any principles for determining over what period of years amortization should be applied?

N. E. WEBSTER:—Each case should be studied separately. However, if there is patent protection for the use of the process, the period may be for seventeen years. If the usefulness of the process is limited to a shorter period by contract arrangements or by anticipated progress of the art which may make the process obsolete, the period for amortization should be shortened accordingly. If the process is not protected by patent, the period for amortization should not extend beyond the earliest date when it may cease to be of value in the productive operations. There is no standard rule except that the treatment should be conservative so as to avoid carrying deferred charges on the balance sheet after they have become valueless to the business.

NOTES ON BURNING REFRACTORIES WITH SPECIAL REFERENCE TO THE CONTROL OF LABOR COSTS[1]

By L. C. HEWITT

ABSTRACT

The tunnel kiln represents up-to-date practice. It is often possible, however, to greatly increase the efficiency of present equipment by keeping in mind the importance of such factors as the setting of dry ware, regular inspection of underground flues, provision for ample grate and flue area, use of burning records, study of vitrification curve, etc.

While the above factors are treated rather generally, more specific reference is made to the control of labor costs through the bonus system. A theoretical problem is worked out to show how the bonus system is applied and in what manner it benefits the employer and employee.

Introduction

Object in Burning.—In burning refractories, high quality ware is, of course, the paramount object to be secured, whether it is kiln design, burning schedule, kind of coal, type of setting, or whatever the particular burning phase may be that is up for consideration. The next object is to obtain this high quality ware at the lowest possible cost.

Tunnel Kiln up-to-date Method.—While the tunnel kiln is, no doubt, soon to come to the front as the most efficient method of burning certain

[1] Presented before the Refractories Division, Pittsburgh meeting, February, 1923.

types of refractories, due to nicety of control, reduced firing labor and handling costs, lower fuel consumption, quick turnover, and higher percentage of first quality ware that such a unit carries with it, it is to be recognized that there is to be no sudden change from present equipment over to this up-to-date method. Production must be continued during such a transition and such factors as plant layout, financial situation, etc., may make a change from present burning equipment in some plants practically prohibitive.

Increased Efficiency Possible with Present Equipment.—It is oftentimes the case, however, that it is possible to obtain greatly increased efficiency from the present equipment through slight changes in design, method of firing, type of setting, etc.

Inasmuch as the control of burning labor is the chief object of this paper, only brief mention will be made of other factors having an important bearing on increased burning efficiency. It is assumed that this industry, as a whole, is largely equipped with some form of the down-draft periodical kiln. While these other factors that will be mentioned are generally known, some of them are often overlooked in the daily routine of plant operation.

General Factors Having Bearing on Burning Efficiency

Set Dry Ware.—It cannot be emphasized too strongly that ware should be dry when it is set. Wet ware means longer burning time, with the tying up of costly equipment and it is often attendant with a lower quality product. It is very seldom that the kiln is an efficient dryer.

Inspect Flues Regularly.—Another important factor, which is often overlooked, is the provision of regular inspection of the underground flues and ducts. It takes draft to burn a kiln and up to a certain limit we can almost safely assume that the burning time is proportionate to the draft. This is particularly true in the water smoking stage, when the entire object is to relieve the ware of its moisture content. Fallen brick from the flue arch, the collection of setting sand, etc., reduces the flue area and hence the draft.

Size of Stack Flue Important.—The size of the flues connecting kiln and stack should also be carefully measured and compared to the area of the kiln bottom flues which feed them, for the effective flue area is no greater than the neck of the bottle in the circuit. The cost of tearing up and enlarging the stack flue is often very small in comparison to the benefits to be derived. Get them too large rather than too small; it takes only a minute to lower the stack damper if the draft is too strong.

Kiln Design.—A discussion of kiln bottom design, type of grates, etc., are subjects which cannot be properly treated in a general discussion. In brief, here again, the grate area should be too large rather than too

small and care should be taken in the floor design that the draft will be evenly balanced. The writer favors some type of so-called open bottom.

Burning Schedule and Records.—The pyrometer is, of course, an invaluable aid in working out and controlling the burning schedule. The vitrification curve of the particular fire clay used can also be employed to good advantage in this problem. If the shrinkage and porosity curve shows that there is little change in the clay over a rather wide range in temperature, and if ware can be secured which possesses the necessary strength, etc., by burning to a lower point of the curve in which the vitrification has been stabilized, often times considerable fuel and labor can be saved by thus limiting the vitrification period. Again, the vitrification curve may show that the burning is not being brought along to the extent that it should in order to relieve the ware of its fire shrinkage.

It is also well recognized that detailed records should be kept of each and every burn so that an analysis may be made of the factors which are conducive to high quality ware at low cost.

Controlling Labor Costs.—Passing on from these general notes, a more detailed reference will be made to the control of firing labor, it having been the writer's good fortune to have spent several months in working on this particular phase of burning in conjunction with Dwight T. Farnham, Industrial Engineer. The January 25th issue of *Brick and Clay Record* of 1921 contained an article by the writer on "Putting the Kiln Firemen on Bonus." Since the Program Committee of the Refractories Division were desirous of presenting a symposium of burning refractories at this time, and since the publications of the SOCIETY do not treat in detail this particular method of controlling burning labor, the *Brick and Clay Record* have kindly assented to the use of the subject matter of that article in this discussion.

Putting the Kiln Firemen on Bonus

Time Study Basis of Labor Standardization.—In working out a bonus system, there must be labor standardization and to standardize properly labor, time or motion study must be employed. Briefly speaking, time study consists of analyzing a job, breaking it up into its component parts, determining the time necessary for the accomplishment of each element, and then combining the results; unnecessary movements are brought to light and methods at once suggest themselves for increasing the efficiency of the task.

Benefits Derived from Bonus System.—But what is to be gained by this so-called time study and labor standardization? The answer is mutual benefits to employer and employee. The employee increases his earnings by receiving a bonus, while the employer increases his profits through more efficient operation.

Working out the Bonus System: Theoretical Problem

Kind of Kilns.—Turning to the method of putting the kiln fireman on bonus—let us first take a walk through the factory; let us assume that we find the yard equipped with nine kilns, six of which are of the round down-draft type and three of which are of the rectangular down-draft type, and that in respect to fire holes we find them classified as outlined in Table I. It is concerning these facts of which we first wish to inform ourselves, since the labor required for firing a certain kiln is dependent upon the number of fire holes. That is granting that the fire holes are evenly spaced, of the same size and kind, it will obviously take twice as long to fire ten fire holes as it will five, etc.

TABLE I

KILN CLASSIFICATION

Kiln no.	Kind of kiln	No. of fire holes
A	Round	8
B	Round	8
C	Round	8
D	Round	9
E	Round	10
F	Round	10
G	Rectangular	18
H	Rectangular	20
I	Rectangular	22

NOTE: The types of kilns and conditions named in this article are purely hypothetical—being used merely to illustrate the case.

Firing Labor Operations.—Now turning to the duties of the firemen, we find that they are divided into the following component labor operations:

1. Placing of kindling wood and coal in fire boxes preparatory to lighting.
2. Firing of kiln at stated intervals.
3. Cleaning of fires and removing ashes.
4. Miscellaneous—such as taking trials, temperature readings, daubing of crown holes, etc.

Relation of Labor Operations to Kiln Temperature.—Since it is evident that the work becomes heavier as the kiln gains in temperature and that this condition at once gives us a basis for setting the Labor Standard, it is next necessary that we determine the relation between the labor operations and the progress of the kiln. Let us assume that the type of ware burned permits the kilns to be put under high fire at 72 hours, the burn being finished in 120 hours, and that the major operations of firing are tied in as outlined in Table II.

Actual Time for Each Labor Operation per Fire Hole.—Thus far we have analyzed the job and broken it up into its component parts. Our

TABLE II

LABOR OPERATIONS PER STAGE OF BURN

Shift	Hours under fire	Temp. F	No. times fired	Frequency and kind of cleaning	No. loads ashes per fire hole
1st Night.....	12	160	5	"Shaking bars slightly"	...
Day.....	24	250	6		...
2nd Night.....	36	500	8		...
Day.....	48	800	12	Use hook once	0.7
3rd Night.....	60	1150	12	Use hook once	0.6
Day.....	72	1400	12	Use spade once	1.0
4th Night.....	84	1600	12	Use spade twice	1.4
Day.....	96	1800	12	Use spade twice	1.4
5th Night.....	108	2000	12	Use spade twice	1.4
Day.....	120	2150	12	Use spade twice	1.4

next step is to take the stop watch and determine the time necessary for the completion of each element of the task, which we may find to be as shown in Table III.

TABLE III

ELEMENTARY TIME STUDIES

Base, one fire hole, time given in minutes for each occurrence of firing or cleaning

Shift	Flat arches		Removing ashes
	Firing	Cleaning	
1st Night.....	1.0	...	....
Day.....	1.0	...	....
2nd Night.....	1.0	...	....
Day.....	1.0	5.0	8.5 minutes per load
3rd Night.....	1.0	5.0	
Day.....	1.5	6.5	
4th Night.....	2.0	8.0	
Day.....	2.0	8.0	
5th Night.....	2.0	8.0	
Day.....	2.0	8.0	

We can now combine the results given in Tables I to III since we have the main facts necessary for determining the Labor Standard. For instance, if we wish to know the time required for firing one fire hole during any one shift, we need only to multiply the time required for one fire by the total number of fires made; the time required for firing one fire hole during the fourth day, is found by multiplying 2 (see Table III) by 12 (see Table II). Likewise we find that the time for cleaning fires on this day is 16 minutes and that removing ashes takes 12 minutes. By applying this method throughout the burn, we obtain the results shown in Table IV.

Fatigue Allowance.—To permit a 50% fatigue allowance, it will be noted that the total man minutes shown for any one shift has been multiplied by 2. This allowance is purely assumed for this particular case, as no arbitrary figure can be set to cover all plants, but as kiln firing is very

TABLE IV

COMBINATION OF TIME STUDIES

Time in minutes—base one fire hole

Shift	Hrs. under fire	Temp. F.	Time for firing	Time for cl'n'g fires	Time for rem'g ashes	Total man minutes req'd.	Total man minutes req'd. × 2
1st Night	12	160	5.0	..	..	5.0	10
Day	24	250	6.0	..	..	6.0	12
2nd Night	36	500	8.0	..	..	8.0	16
Day	48	800	12.0	5.0	6.0	23.0	46
3rd Night	60	1150	12.0	5.0	5.0	22.0	44
Day	72	1400	18.0	6.5	8.5	33.0	66
4th Night	84	1600	24.0	16.0	12.0	52.0	104
Day	96	1800	24.0	16.0	12.0	52.0	104
5th Night	108	2000	24.0	16.0	12.0	52.0	104
Day	120	2150	24.0	16.0	12.0	52.0	104

heavy and hot work, a considerable period of rest must be allowed if the men are not to be overtaxed. This fatigue allowance also covers such miscellaneous duties as daubing crown hole covers, taking trials, etc.

Application of Standards to Each Class of Kiln.—Our next process is to apply the standards obtained per fire hole to each class of kiln. This procedure is outlined in Table V.

TABLE V

APPLICATION OF COMBINED TIME STUDIES FOR ONE FIRE HOLE TO AN 8 FLAT GRATE FIRE HOLE, ROUND KILN (NOS. A, B AND C.—SEE TABLE I)

Shift	Hours under fire	Temp. deg. Fahr.	Man min.[1] req'd including fatigue	Man min. reduced to man hours	Standard no. man hours selected
1st Night	12	160	80	1.3	2
Day	24	250	96	1.6	2
2nd Night	36	500	128	2.1	2
Day	48	800	368	6.1	6
3rd Night	60	1150	352	5.8	6
Day	72	1400	528	8.8	9
4th Night	84	1600	832	13.8	14
Day	96	1800	832	13.8	14
5th Night	108	2000	832	13.8	14
Day	120	2150	832	13.8	14

[1] Found by multiplying the minutes set for one fire hole (right hand column Table IV) by 8, the total number of fire holes.

In order to make the scheme as simple as possible, standards have been set to cover as wide a range of the burn as the circumstances permit. (See right hand column Table V.) The Labor Standard for an 8-fire-hole kiln is then 2 man hours from start of burn to 500°, 6 man hours from 500° to 1150°, 9 man hours from 1150° to 1400°, and 14 man hours from 1400° to finish of burn.

By applying this method to the various kilns listed in Table I we obtain the standards shown in Table VI.

TABLE VI

STANDARD MAN HOURS PER 12 HOUR SHIFT—PER STAGE OF FIRE

Kiln numbers	Temperature range 0–500	500–1150	1150–1400	1400-fin.	Standard man hrs. for lighting[1]
A-B-C	2.0	6.0	9.0	14.0	2.0
D	2.0	7.0	10.0	15.5	2.5
E-F	2.5	7.5	11.0	17.5	3.0
G	4.0	13.5	20.0	31.0	5.0
H	5.0	15.0	22.0	35.0	6.0
I	4.5	16.5	24.0	38.0	7.0

[1] Determined from actual time study.

. It will be noted that in a number of instances the standards call for as low as 2 man hours or $^1/_6$ of a man. But how can we dispense with the services of part of a man? This, of course, cannot be done—but the standards adjust themselves when there are a number of kilns on fire. If kiln D was in the 2nd stage and kiln H was in the 1st stage, the total standard man hours would be twelve, or one man. There would be times, undoubtedly, when the standard would not call for an even number of men, but the scheme works out very well on an average. If the total standard of all kilns on fire called for 23 man hours, 2 men would necessarily be needed, while again if the standard called for 25 man hours, two men could still do the work and would then be over 100% efficient. It is a give and take proposition.

Flexibility of Standards.—Standards set as above can be applied to other burning schedules than the one from which the standards were deduced; *i. e.*, if on account of wet tile, it was not safe to reach 500° until after 48 hours had elapsed instead of 36, we would still use the labor standards for the range 0–500°.

Standards Once Set Should not be Changed.—It is to be remembered, however, that the success of the bonus scheme as a whole, is necessarily dependent upon the correctness of the standards set—which correctness, is in turn, dependent upon the man who sets the standards. This man who must be thoroughly grounded in the fundamentals of time study, should be capable of judging in his own mind whether the worker, whom he is timing, is doing a "fair day's work." Obviously, we would not set standards based upon the movements of the most efficient worker in the crew, any more than we would set standards based upon the least efficient; neither would we attempt to set the standard time for a given task until we had repeatedly timed the operation and assured ourselves that no stone had been left unturned in arriving at our conclusions. If the bonus system is to retain the mutual respect of company and men—standards once set

should *never* be changed unless conditions are changed—therefore the importance of correct standards.

Reward to Labor.—Turning again to the calculation; since we have now established a standard labor schedule how shall the firemen be rewarded for attaining this standard? We might base their premium on either a 10, 15 or 20% bonus curve, depending upon the attendant circumstances. Let us select the 15% curve as the standard in this particular instance.

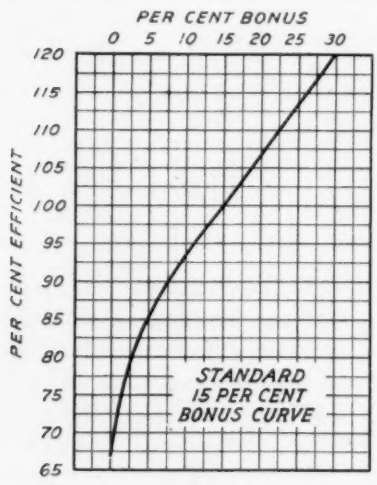


FIG. 1.

On this basis then each fireman will receive 15% additional wages for obtaining standard or being 100 per cent efficient. If only 90% efficiency is attained the bonus would come to 7.5%. A comparison between various efficiencies and bonus reward is shown in Figure 1.

How Company Gains.—The above procedure takes care of the fireman, he can increase his earnings 15% without undue exertion—but how about the company? Experience has shown that on most unstandardized work, labor efficiency approximates 70%. On this basis then, to reach standard—the firing force must consist of 7 men where there were ten—or in other words the force must be cut 30%. The company then will accordingly reduce its gross labor bill for firing 30%, paying out 70 cents where it spent $1 before. As against this saving of 30%, the company must pay a bonus of 15 per cent, on each 70 cents paid for labor or 10.5 cents. The total labor bill will then be 80.5 cents instead of $1, and the company will have realized a net saving of 19.5%.

It is also desirable in connection with the labor bonus to pay the firemen an additional bonus for attaining standards set on burning time, coal consumption and quality of product. We then have an ideal method for basis of payment, the reward is in proportion to accomplishment, the the fireman has been set up in business for himself, as his interests are identical with that of the company—namely to produce the highest quality ware, burned in the shortest time, with the least amount of coal and with the least amount of labor possible.

RESEARCH DEPARTMENT
LACLEDE-CHRISTY CLAY PRODUCTS CO.
ST. LOUIS, MO.

DISCUSSION ON "THE AMERICAN INTEREST IN CHINESE ART"

FREDERICK H. RHEAD:—The American interest in Chinese art is largely a collectors' interest, but more fundamentally, it is a students' interest.

China, in common with Greece, Persia, Italy and Japan, is one of the relatively few countries which has developed a national style of art which has been the inspiration to artists and craftsmen in most other countries.

The United States has not yet developed a strictly national style, although we are developing a school of architecture that is distinctly American. Our skyscrapers are responsible for this, but we are to a great extent following the European countries in drawing on Grecian, Renaissance, Gothic—and in the West, Spanish styles and adapting these to our own needs.

Owing to the peculiar construction of Chinese and Japanese architecture neither of these has been an influence in this respect. China and Japan are the only nations in the world where the capital, the principal ornamental feature of all other architectural styles, is unknown. But so far as bronzes, porcelains, jades, crystals, embroideries and ornamental detail are concerned, the Chinese designers and craftsmen have produced work which has influenced the Occidental artists and craftsmen, just as our architects have been influenced by the other periods named.

It is easy to understand that a country with no great national art will turn to those countries possessing distinctive types, and in the search for inspiration, the artists and sculptors will be influenced by the various masterpieces irrespective of their original source.

The period of growth, the highest point of development and the inevitable decline of a particular style has generally occupied a space of something like four hundred years. We find the greatest period of the Grecian vase development to be in the fourth century, B.C., the Della Robbia majolica vase about 1438, and the K'ang-shi period in China 1662–1722.

In all these great developments there is ample evidence that the activity has been under the protection of the reigning potentate, or subsidized by the respective government. A national interest, or a powerful individual interest in an art or science is bound to be productive because the means are provided to bring about the necessary development. As the Royal Sevres, Berlin and Copenhagen factories could not produce their fine works if France, Germany and Denmark did not contribute towards their support, it is very definite that the great historical art and architectural works would not have been produced if the reigning monarch of the period was not personally interested.

In China a revolution always resulted in an interruption in connection with her artistic development.

In the United States we have evidence of the necessity of subsidized or protected activities in the arts. It is only necessary to refer to the

various symphonic and operatic organizations. The big schools, libraries, and the museums must be endowed, and even our own Rookwood Pottery could not have continued its existence if it had not been liberally supported for a number of years before it became self-supporting. Then again, we need a Woolworth to build an epic in sky-scrapers, and a Stanford White to build a Madison Square Garden, one of the finest pieces of Renaissance architecture in this country.

The United States is awakening to the need of national art development, and is only following the steps of England and other European countries in turning to the great classical styles of Greece, Persia, China and Italy for inspiration.

Various artists seek different inspirations, interpreting these according to their individualistic skill and ability.

In the ceramic world, we find practically in the same period, Wedgwood using the Grecian motifs, while a number of the English porcelain manufacturers are copying the Chinese.

In the same way our artists and craftsmen are reaching out for the best that has been produced in other countries with the result that in course of time we will have absorbed what has been done before, and will consciously or unconsciously develop a great historic style of our own. In fact, we are already doing this.

New York at this time is admittedly the center of art in the world; chiefly because it is the greatest art market in the world, but also because of building activities such as the world has never known before. And all the arts are subsidiary or subordinate to that of architecture.

In looking for the best art work that has been done by other countries, we cannot as stated follow China in regard to architecture, but we can and do follow her decorative styles. The St. Louis Exposition of 1904 and the San Francisco Exposition of 1915 have no doubt been responsible for an increased popular interest in Chinese art, but the intellectual interest dates back further than this.

It dates back to the beginning of the growth of big business when individuals who had amassed great fortunes found the time to collect, and discovered the need of ownership of fine works of art.

Art is one of the great essentials of desirable human existence. Even the primitives discovered this. Directly the American business man developed his industries to the point where they are no longer individual activities, he would have the means and the time to acquire beautiful things for his surroundings.

That Chinese porcelains, rugs, jades and embroideries would be included is obvious, and it is equally obvious that the acquisition of such works by the wealthy would create a vogue or style which would be more or less popular among the general public.

This interest is reflected not only in connection with objects of art, but it is seen in the theater, the photoplay and in literature.

However, this national interest in foreign art is not permanent, or at least it is not to be the dominating influence. This country is too large and has contributed too much to the development of human accomplishment to be lacking in material, subject and epic for the artist, sculptor, craftsman and writer.

DISCUSSION ON "CAUSES OF BULGES ON STRUCK-OFF FIRE CLAY SHAPES"[1]

What is the cause of bulges or bellies upon the struck-off face of fire clay shapes molded by hand in wooden molds and not repressed, and what is the remedy for same?

E. H. VAN SCHOICK:—It may be that this trouble is peculiar to our plant; we find that we have lots of trouble in making the simplest kind of a fire clay shape, as much as we do the most difficult one. About the simplest fire clay shape you can make would be a cube, say 10 or 11 inches square, and we find when we mold that shape by simply throwing the clay into the mold, and after that shape is dry, it will have a bulge on the side where it has been struck off, and after it is burned, the bulge will be still more pronounced. We have tried certain ways of remedying that, in our own plant, none of which has ever proved satisfactory except in certain particular cases. I was wondering if there was something radically wrong with our general method of molding these shapes.

To my mind, the cause is a greater density of clay through the center; we have endeavored to prevent this by hollowing out the center, deliberately hollowing it out, on one particular shape that we made. This was a shape for a flat arch. If you can hang your brick so that the bulged face only goes to the back, then you will get a tight joint, even if one face is bulged a little, because the other face will be slightly concave, but in those cases where the brick hang back to back, it causes a very pronounced opening in the arch. We hollowed out the clay on the top of the mold and filled up the hollow space with white sand. After it had dried, we had a hollow of $^3/_{16}$ of an inch deep in the top of a brick which did not measure over 10 inches across. After these brick were dried enough they were set back to back and when they came out of the kiln they were perfectly straight, with the dimensions through the center the same as the outside. It would seem that there is a greater density of the clay through the center.

F. TALBOT:—I think he is on the right track to prevent this trouble, that is, to concave one surface of the tile.

E. H. VAN SCHOICK:—Some of the men in our plant thought it was be-

[1] Discussion on Question R-26 at St. Louis Meeting, February, 1922.

cause the tile dried out faster on the top. The tile is put onto the floor on the struck-off face. We tried turning the tile onto its side, but no matter how we handled it after the tile was made, we always got the bulge.

F. H. SCHWETYE:—We have that same trouble at times, and we think it is caused sometimes by improperly making up grog and also by slicking cut off surface of tile.

We have taken tile which showed a bulge after it was burned, and broken it and found a void inside. This we attributed to poor molders, who made up grog improperly. Other tile that showed a bulge were solid and as sound as it would be possible to make them. We found these bulges due to slicking top of tile after cap was cut off.

We overcame this trouble by discontinuing slicking the cut off side. Instead of slicking we cut off the cap and branded the tile. We placed a convex board on top of tile, raised $^1/_{16}$ to $^1/_8$ inch depending on size of tile, and struck board with a mallet. We found this would overcome the bulging. When handling a fairly heavy tile this way we filled the hollow space with sand before turning out of mold onto offbearing or drying board.

We have most of our trouble with mixtures containing a large per cent of plastic clay, a fairly dense product. There is a resiliency to plastic clay when wet. You can compress it slightly when slicking causing body of clay near surface to be moved from its original position, and when slicking plane is removed you will leave a greater volume of clay in one spot than in another, causing bulge. The tile retains this shape through drying and burning. We still have the trouble and we have attempted to remedy it the same as you have by making the bottom slightly convex and also by putting it onto a block and putting sand on it.

A. F. GREAVES-WALKER:—Could this difficulty be due to slicking? When you run the slicker over the mold you in a measure compress or tend to compress more clay into the mold than it will hold. The clay mass will be compressed slightly as long as the slicker is on top but as soon as the slicker moves off the resiliency of wet clay will allow the clay mass to recover most of its original volume.

F. H. SCHWETYE:—We found that to be true. We overcame it by trimming the tile off. We cut it off but did not slick it, and then placed the convex surface of the board on top of the tile. In slicking you increase the pressure on your clay and its resiliency causes the clay to come back to its original shape.

E. H. VAN SCHOICK:—We have used the same remedy. Where we slicked the tile with water, we now simply cut them off and place the tile onto a slightly convex board; thus a slightly concave surface is obtained on the tile.

F. H. SCHWETYE:—We have that trouble, only with some clays, not all of them.

MR. GREAVES-WALKER:—The trouble seems to be more with the plastic clays than with the non-plastic, which indicates that it is due to the resiliency of the clay.

A MEMBER:—Would it do any good to vent the shape, say by puncturing the tile after it had been formed? If the bulging was due to gas, it might be remedied by allowing the gas to escape.

E. H. VAN SCHOICK:—We punched our tiles full of all kinds of holes.

A MEMBER:—In tiles that have been slicked, it will be found in many cases that the trowel has forced the coarse particles down to a depth of three-sixteenths of an inch. That portion at least, is of much finer grain than the rest of the tile. When you get coarse and fine materials, you are going to have a difference in shrinking and burning. Take the other side of that, where it has been put on a mold, and you will find that the bottom instead of being of dry material, in that wet mold the coarse will go to the bottom and that gives a tendency to the entire tile to bulge. Additional troweling that the molder often does in finishing it up to make it nice and smooth to look at, forces the coarse part away from the top.

A. F. GREAVES-WALKER:—We run across that difficulty sometimes in the manufacture of magnesite shapes, but it usually occurs when the material is a little too wet. When he has not a perfectly flat surface, the molder takes his fingers and presses out a small amount of material; sometimes he does that twice, and eventually brings it down to a perfectly flat surface, showing that it is caused by too much material.

E. H. VAN SCHOICK:—We use a large proportion of plastic clay in our tile.

A MEMBER:—In using the open burning clays in Northeastern Kentucky we never had any trouble like that at all, but in using some very plastic Indiana clay we have had it and sometimes it causes a great deal of trouble. Can it be that this is possibly due to the expansion of some colloidal matter in the clay? In making up some test bricks of some plastic coal mine clay, I noticed when we tried to mold this mud, it would expand to such a degree that it was almost impossible to get the shape wanted. It seemed to me there was some material there that was expanding.

A. F. GREAVES-WALKER:—I don't know whether we have suggested anything to Mr. Van Schoick that will clear the atmosphere for him or not, but he at least knows that he is getting as good results as the rest of us. There are but a few ways to overcome this difficulty and he probably has them.

DISCUSSION ON THE "MEANING AND MICROSCOPIC MEASUREMENT OF AVERAGE PARTICLE SIZE"[1]

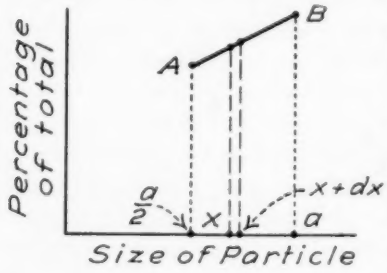
J. C. PEARSON:—This paper should be of considerable interest to those concerned in any way with the properties of finely divided materials, es-

[1] Perrott and Kinney, *Jour. Amer. Ceram. Soc.*, **6** [2], 417–39 (1923).

pecially to those who are interested in methods of determining the gradation of powders too fine to be handled with sieves. The discussion of the meaning of average particle size is a valuable contribution, and the general mathematical treatment will be an aid to many who have tried to interpret the results of mechanical analyses.

The authors have done well to emphasize that the sizes or diameters of irregular particles are wholly arbitrary when one wishes to express and use these quantities in such way as to bring out certain characteristics of a large group of particles as a whole. As this fact is indisputable, it is sometimes convenient and permissible to make certain simple assumptions in regard to shapes and sizes of particles that lend themselves readily to mathematical treatment. Thus one may frequently arrive at an approximate result with a small fraction of the physical and mental effort that he would otherwise be put to.

The question in which the writer is particularly interested is whether the microscopic analysis is, after all, as simple, easy, and satisfactory a method as air elutriation for arriving at the specific result desired by the authors, namely an average particle size of pulverized coal such that one-half the weight of the material consists of particles coarser than this size, and one-half finer than this size. The thought which gave rise to this question was that in the studies of fine aggregates for concrete, we are accustomed to use sieves the openings of which form a geometric progression, the standard methods for sieve analyses of such materials specifying the use of sieves No. 100, 50, 30, 16, etc., in which the constant ratio of 2 is maintained between the openings of the successive sieves. This standard has been adopted by the A.S.T.M. on the general belief that for most purposes the gradation of a fine aggregate is sufficiently well determined by these particular sieves. Assuming this to be true, it is obvious that the computation of "fineness modulus" or "surface modulus," or any other factor based on the mechanical analysis of a graded material is greatly simplified by the simple ratio of sizes which exists between the successive fractions.



As an illustration of this last statement let us find an expression for the number of particles of a graded material passing a given sieve and retained on the next finer sieve of the series.

In the diagram let A and B be two points on the mechanical analysis curve of a graded material, the ordinates of A and B representing the percentages of the total sample passing any two successive sieves, and the abscissae representing the sieve openings, which may be designated as a

and $a/2$. Then the straight line AB is an approximation to the portion of the true sieve analysis curve between A and B, and is the *actual* curve if we assume an even gradation of particles in this fraction.

Let M = total mass of particles between the two sieves and dM = mass of particles with diameters between x and $x + dx$.

$$\text{Then } \frac{dM}{dx} = \frac{M}{a - \frac{a}{2}} = \frac{2M}{a} = K \text{ a constant.} \qquad (1)$$

Let dN = number of particles with diameters between x and $x + dx$. Then $dN = \frac{dM}{mx}$, where mx = mass of particles of diameter x.

Assuming the particles to be spheres, $mx = \frac{\pi\rho x^3}{6}$. From (1) $dM = Kdx$,

$$\text{Hence } dN = \frac{Kdx}{\frac{\pi\rho x^3}{6}} = \frac{6K}{\pi\rho} \cdot \frac{dx}{x^3} \qquad (2)$$

Integrating (2) between the limits a and $\frac{a}{2}$ we get $N = \frac{9K}{\pi\rho a^2}$. Substituting for K from (1)

$$N = \frac{18}{\pi} \cdot \frac{M}{\rho a^3} = 5.73 \frac{V}{a^3} \qquad (3)$$

where N is the total number of particles between the sieves and V is the absolute volume of the particles, which in the case of a homogeneous material is proportional to the weight of the fraction.

Hence under the assumptions made, the number of particles between two consecutive sieves is proportional to their combined weight and inversely as the cube of the openings of the sieves. Equation (3) is of course an approximation to the truth, but possibly near enough for practical purposes. The important thing is that equation (3) holds for every fraction obtained in the sieve analysis, and consequently serves to give a very simple estimate of the total number of particles in a given sample of graded material.

The purpose of this somewhat detailed reference to the advantages of a sieve analysis in which the sizes of separation form a geometric series with a simple ratio of 2 is to suggest that these same advantages are maintained in any sort of a mechanical analysis based on the same ratio of sizes, no matter what methods or what materials are used. Thus in the cement testing laboratory at the Bureau of Standards the air elutriator referred to by the authors has been so adjusted as to give nominally sizes of separation of 40, 20 and 10 microns, these fitting approximately into the geometric series of openings of the testing sieves referred to above. If

pulverized materials for which elutriation methods are applicable are so graded that not too great a proportion of the particles are of nearly the same size, or in other words, if the component particles are well graded in the sense that we speak of a sand for mortar or concrete as being well graded, their properties and characteristics ought to be thus determined as well relatively as are those of fine aggregates by the standard methods of sieve analysis.

It has been interesting therefore to see just what result would have been obtained from elutriation methods alone for the average particle size of the sample of coal used by the authors to illustrate their method of microscopic analysis. In order to do this, it is necessary to assume that the percentages of the several sizes of coal particles as given in the last column at the bottom of page 432 represent approximately the true mechanical analysis of the sample, whether these were obtained by microscopic analysis or by elutriation methods. From the figures given we find the following distribution of sizes:

10 microns	12.6%
20 microns	16.8
40 microns	33.2
60 microns	37.4
Total	100.0%

The number of particles in each of these groups is, as indicated in the previous discussion of sieve separations, proportional to the percentage by weight and inversely to the cube of the separation size, but because the limiting size of the coarsest fraction does not fall in the geometric series, a different constant of proportionality must be determined for the 40–60 fraction above. This is easily found by substituting in the derivation of the N formula the integration limits a and $\frac{2a}{3}$, from which the number of particles in this coarsest fraction becomes $N = 0.58\,\frac{V}{a^3}$ instead of $N = 5.70\,\frac{V}{a^3}$ for the other fractions.

Remembering now that we may substitute the percentages of the fractions by weight for V, and using the authors' tabular scheme of calculation on page 432, we have

Number of particles	Diameter, microns	$d.^4 \times$ No.	$d.^3 \times$ No.
$5.73 \times 12.6/10^3$	10	722	72.2
$5.73 \times 16.8/20^3$	20	1925	96.3
$5.73 \times 33.2/40^3$	40	7610	190.2
$3.58 \times 37.4/60^3$	60	8035	133.9
	Sums	18292	492.6

$$\text{Average diameter} = \frac{18292}{492.6} = 37.1 \text{ microns.}$$

This value is in very close agreement with that deduced by the authors, and the writer is therefore of the opinion that the elutriation method is at least capable of giving a satisfactory result.

From the data presented in the paper, the writer is far from convinced that the "amount of time saved by the elimination of the elutriation procedure is enormous." On the contrary the eye-strain and mental effort accompanying the count and estimate of size of many hundreds of particles, the lengthy computations involved, and the many chances for error to creep in, would seem to urge the investigator to find some simpler method. The authors have evidently not appreciated the virtues of the air elutriator, by means of which the complete analysis and exceedingly simple computations involved would require at most two days, one of these being allowed for the 10 micron separation. During these days many other duties might be performed while the elutriator was automatically doing the major portion of the work without attention from the operator.

THE CERAMIC ENGINEERING DEPARTMENT OF THE UNIVERSITY OF WASHINGTON, SEATTLE, WASHINGTON[1]

By Hewitt Wilson

Educational

A four-year curriculum in ceramic engineering has been developed and tried out at the University of Washington, Seattle, Wash. It is based on the ceramic instruction given at the Ohio State University and the University of Illinois, but with more training in the geology and working of clay deposits. During the development period of this complete program, elective courses in cements, limes, and plasters, refractories, and general ceramics have proven popular with the civil, metallurgical, and chemical students.

The Ceramic Laboratory

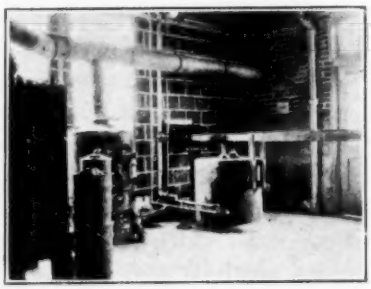
A ceramic laboratory occupying 7,350 sq. ft. total floor space has been built and equipped with the best types of ceramic machinery. It is the only public ceramic laboratory on the Pacific Coast and compares very favorably with the best in the eastern parts of the United States. The ceramic department is housed in the New Mines Laboratory (1921) which is the first building erected in the New Mines group and is the latest representative of the collegiate Gothic style of architecture adopted by the University. The structure is four stories in height, with steel frame, reinforced concrete walls and floors, brick face, terra cotta trim, and slate roof with copper trimmings. A special feature of the building is the unusually large window area. An electric elevator serves all floors; hot and cold water, steam, compressed air, gas, and electricity for lighting, power, and electrolytic purposes, reach all the laboratories.

The ceramic laboratories, together with the offices and classrooms, occupy the northern two-fifths of the building, including the main entrance hall. Apparatus for both manufacturing and testing ceramic products has been provided. The heavy brick

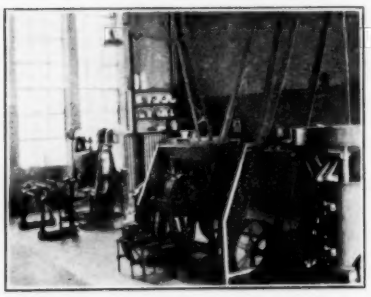
[1] See Wilson, *Jour. Amer. Ceram. Soc.*, **6** [1] 110–14 (1923).

machinery, located on the first or ground floor, consists of a 4-foot Crossley dry and wet pan, a Mueller universal auger machine large enough for side-cut brick and tile with a cutting table, and a large American dry press. The pottery machinery includes a Pat-

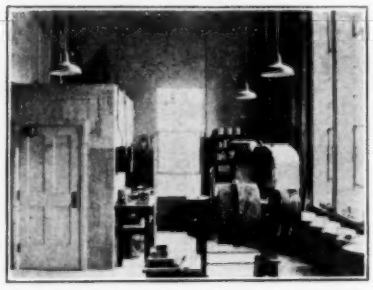
Corner in Ceramic Physical Chemical Laboratory.



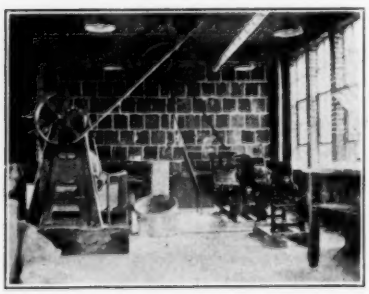
High temperature load test kiln.



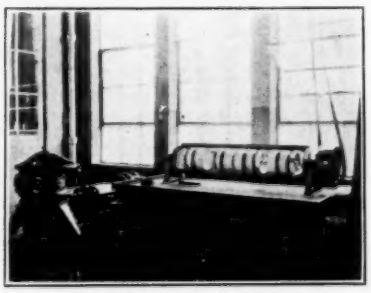
Pottery and brick machinery.



Spraying and grinding machinery.



Heavy clay products machinery.



Grinding equipment..

terson clay-washing outfit with a double blunger, power screen, agitator, pump and filter press operated with compressed air; a potter's pug mill; jolly wheel and plaster molds for both jollying and casting ware. The terra cotta equipment consists of pressing molds, a De Vilbiss spraying apparatus, engobe and glaze materials and glaze-grinding ball

TABLE I

CERAMIC ENGINEERING CURRICULUM

Autumn Quarter	Credits	Winter Quarter	Credits	Spring Quarter	Credits
First Year					
Mathematics 51	4	Mathematics 52	4	Mathematics 53	4
Civil Engineering 1	3	Civil Engineering 2	3	Civil Engineering 13	3
Civil Engineering 11	3	Civil Engineering 12	3	Civil Engineering 21	3
Chemistry 1 or 21	5	Chemistry 2 or 22	5	Chemistry 3 or 23	5
Mil. Sci. or Phys. Ed.	1⅔	Mil. Sci. or Phys. Ed.	1⅔	Mil. Sci. or Phys. Ed.	1⅔
Second Year					
Mathematics 61	3	Mathematics 62	3	Ceramics 90	3
Physics 97	5	Physics 98	5	Physics 99	5
Geology 1	5	Geology 21	5	Geology 120	3
Mining 51	3	Civil Engineering 27	3	Chemistry 111	5
Mil. Sci. or Phys. Ed.	1⅔	Mil. Sci. or Phys. Ed.	1⅔	Mil. Sci. or Phys. Ed.	1⅔
Third Year					
Civil Engineering 131	3	Civil Engineering 132	3	English 4	3
Mining 101	3	Metallurgy 153	3	Metallurgy 102	5
Chemistry 181	3	Chemistry 182	3	Ceramics 102	3
Ceramics 100	3	Ceramics 101	3	Ceramics 110	2
Ceramics 104	3	Ceramics 105	3	Mining 106	2
Mining Practice in Summer Vacations.[1]		**Fourth Year**			
Ceramics 121	5	Ceramics 122	5	Ceramics 123	5
Ceramics 131	3	Ceramics 132	3	Ceramics 133	2
Electives	7	Mining 103	1	Electives	8
		Electives	6		

[1] Practice in mining, metallurgy, geology, or ceramics, accompanied by a report on the work performed is required of all students during a summer vacation following the sophomore or junior year.

mills. The firing apparatus, installed on the first floor includes an oxygen-acetylene cone fusion furnace; a 3-foot, high-temperature, down-draft load-test kiln for two brick; two portable muffle pottery kilns; a 7 by 10-foot open-fired, down-draft brick kiln; and a future 8- by 10-foot terra cotta and glaze kiln of the muffle type. The kilns are equipped with Brown pyrometers and fired with both gas and oil. The underground flues lead to a stack which rises to the full height of the building. General testing apparatus consists of sample molds, a small Mueller auger machine, a sample dry press, aging cellar, three types of volumeters, steam dryer, a constant temperature electric dryer, and transverse and tensile strength machines. The ceramic museum, library, and office, physical-chemical laboratory, and locker room are on the third floor. Lecture, pottery class and storage rooms occupy the fourth floor. Besides the $52,000 ceramic portion of the $130,000 building, over $6,000 has been spent for the purchase and installation of machinery.

Coöperation with the other departments of the University and Bureau of Mines increases the facilities for ceramic work. As one of the chief problems in the Pacific Northwest is the locating and testing of raw materials, the geology department of the College of Science is often called on for advice. For the mining and winning of the raw materials, the experts of the mining department are available. The analytical department of the Bureau of Mines coöperates in the analysis of clay and materials; and the special equipment of the forest products laboratory and the chemical, civil, mechanical, electrical, and highway departments may be used when necessary. The electrometallurgy laboratory is equipped with transformers, voltage regulators, and switchboard, through which power can be used at rates ranging up to 3600 amperes and at voltages varying from 1 to 484. Advantage has been taken of the electrical equipment in a special study of super-refractories, in which clays, sillimanite, and magnesia mixtures have been fused.

Courses in Ceramics

90. Ceramic Materials.—Origin, occurrence, physical properties and preparation of clays, feldspar, limestone, magnesite, silica, and other materials used in the ceramic industry. Prerequisite, sophomore engineering or mining standing. Three lectures and recitations. Three credits; spring.

100. Ceramic Products.—Principles governing the shaping of structural, refractory and fine ceramic wares. Prerequisite, Ceramics 90. Three lectures. Three credits; autumn.

101. Drying and Burning.—The principles of drying and burning; the operation and control of commercial dryers and kilns. Prerequisite, Ceramics 100. Three lectures and recitations. Three credits; winter.

102. Ceramic Decoration.—The preparation and characteristics of vapor, natural clay slip, raw lead, bristol, terra cotta, porcelain and fritted glazes, bright and matt, with methods of coloring. Prerequisite, Ceramics 101. Three lectures and recitations. Three credits; spring.

104, 105. Ceramic Calculations.—The chemistry and physics of preparing, drying and firing ceramic materials. Problems involved in standard methods of testing clays. The blending of raw materials for ceramic bodies and glazes. Prerequisite, Ceramics 90. Three recitations. Three credits; autumn and winter.

110. Ceramic Physical-Chemical Measurements.—Laboratory testing of clays and other ceramic materials. Determination of fineness of grain, shrinkage, porosity and specific gravity; the study of plasticity, bonding power, vitrification and fusion, chemical purification and action of colloids. Prerequisite, Ceramics 105. Laboratory deposit, $10 per quarter. Two laboratory periods. Two credits; spring.

121, 122, 123. Ceramic Products Laboratory.—Laboratory production of structural wares, stoneware, yellow ware, porcelain and refractories. Practice in blending of ceramic materials, molding, drying, firing and glazing ceramic products. Prerequisite, Ceramics 101. Laboratory deposit, $12 per quarter. Three laboratory periods and two recitations. Five credits per quarter; autumn, winter, and spring.

125, 126, 127. Ceramic Plant Design.—Design of ceramic plants. Arrangement of machinery and construction of storage bins, dryers and kilns. Prerequisite, Ceramics 101. Two laboratory periods and one recitation. Three credits; autumn, winter, and spring.

131, 132, 133. Ceramic Thesis.—An original investigation, bearing principally on the ceramic problems of the Pacific Northwest. Laboratory deposit, $5 to $10 per quarter. Laboratory and conference. Three credits, autumn and winter; two credits, spring.

140. Pottery.—Occurrence, winning and preparation of materials used in pottery manufacture. Processes used in molding, drying, firing, glazing, and decorating of pottery. Two lectures and recitations. Two credits; autumn.

150. Lime, Plasters and Cements.—The raw materials, manufacture and testing of lime, calcined gypsum, sand-lime brick, and Portland cement. Prerequisite, Chem. 3. Three lectures and recitations. Three credits; winter.

160. Glass Technology.—Theory and factory practice of glass manufacture. Prerequisite, Ceramics 105. Two lectures and recitations. Two credits; autumn.

170. Metal Enamels.—Theory and practice of metal enameling. Prerequisite, Ceramics 105. Two lectures and recitations. Two credits; autumn.

180. Refractories.—Origin, occurrence and physical properties of fire clays and other refractory materials. The manufacturing problems of fire clay, silica, magnesia, chromite brick, electric furnace products and special refractories. Prerequisite, junior standing. Two recitations and one laboratory period. Laboratory deposit, $5. Three credits per quarter; autumn, winter or spring.

191, 192, 193. General Ceramics.—Occurrence, winning and preparation of materials used in ceramics. Processes used in preparation of raw materials, shaping, drying and firing of ceramic products. One recitation and two laboratory periods. Laboratory deposit, $10. Three credits; autumn, winter and spring.

221, 222, 223. Ceramic Resources.—A study of the ceramic resources of Washington and the Pacific Northwest, or of some particular area in this region. Prerequisite, graduate standing. Hours and credits to be arranged.

231, 232, 233. Ceramics Manufacture.—Studies in the manufacture of clay products, especially the utilization of raw materials found in the Pacific Northwest. Prerequisite, graduate standing. Hours and credits to be arranged.

UNIV. OF WASHINGTON
SEATTLE, WASH.

PRESIDENT'S PAGE

AIMS OF THE AMERICAN CERAMIC SOCIETY

In this, my first appearance on the President's page, I wish to call the attention of the members to some of the more important things which the officers wish to accomplish during the year.

Of first importance is the fact that the Budget Committee laid out a financial program which calls for approximately $9,000 above the 1922 income. It was found necessary to do this if the work of the SOCIETY was to go forward. This additional $9,000 must come from two sources: advertising in the *Journal*, and new members. It, therefore, becomes the duty of every member interested in this SOCIETY to add to the *Journal* advertisements and it is further important that the membership encourage advertising in the *Journal* by patronizing, whenever possible, the advertisers and neglecting in no instance to call the attention of our advertisers to the fact that their advertisements are being read.

There are undoubtedly hundreds of men interested in some branch of our industry, especially among the consumers, who would willingly join the SOCIETY, either as a Corporation member or Associate member, if the matter was called to their attention. Will not each member of the SOCIETY constitute himself a member of the Membership Committee and "leave no stone unturned" to interest new men in joining us?

It is the hope of the officers that new life will be injected into the Sections which already exist and that a number of new Sections will be formed during the year. Preliminary moves to form new Sections have already been made in Detroit, East Liverpool, Baltimore-Washington and Los Angeles. It is hoped that members living in these districts will give their whole hearted support to the men who are making the initial moves.

In order that the SOCIETY may function as a promoter of ceramic research it is extremely desirable that the Research Committees of the various Divisions make up a list of the important research problems in their particular branch of the industry. Heads of the Ceramic Schools and the Directors of the Bureaus, as well as the heads of the various Departments of Engineering in Universities all over the country will welcome suggestions and much good and valuable work can be gotten under way in this manner.

ACTIVITIES OF THE SOCIETY

ALL OUT FOR THE BARNYARD GOLF SQUAD!

Professional sporting writers no doubt turn their thumbs down and their noses up at intramural sports, but this only sends our opinion of them lower and of ourselves higher, for we have had more fun this month watching our members pitch horseshoes and shoot—marbles. Every day at ten-thirty and at two-thirty the lists were thrown open with a paper-knife and all entries noted. The University of Illinois Ceramic department sent a gallant team, to wit, Hursh and Parmelee. These two for a while tied for first place in the horseshoe parallelogram, but Hursh dropped ballast by cashing some of the AMERICAN CERAMIC SOCIETY bonds and was able to make another ringer, thus putting himself ahead. Sam Wilkinson of Trenton went west for early spring practice and brought back a record flight of the lucky omens.

What we like to see best is the staid officials of weighty corporations, and the important carriers of government-owned brief cases, throwing off their coats and cares to enter into the sport. Look at the list—W. B. Kerr, C. F. Tefft, L. I. Shaw, A. S. Watts, Karl Türk, to mention only a few.

Like lambs in the springtime, the younger members gamboled on the green (roll along, mah beauties), and did their share of increasing the general joy.

To come down to brass tacks, U. S. currency, there were twenty-five persons who advertised the SOCIETY, eight more than last month, with a consequent increase of eight in the number of converts. The needed average of personal memberships, 7.31 a week, has been more than reached. That the needed average of corporation memberships was not reached, means that we must concentrate. Seat yourself firmly before your desk, press the thumbs and forefingers together, close the eyes and *think* of a prospective Corporation Member. Seize the telephone or your hat, and call up or on said prospect. Mail the resulting card to the Secretary of the SOCIETY and receive your due in the June number of the *Journal*. Go at least one better than these:

	Personal	Corporation
R. K. Hursh	3	
C. W. Parmelee	2	
Samuel Wilkinson	2	
Charles A. Smith	1	
Lawrence H. Brown	1	
C. E. Fulton	1	
Paul K. Klaesius	1	
Hobart M. Kraner	1	
A. L. Duhart	1	
L. I. Shaw	1	
Horace H. Clark	1	
Leon J. Frost	1	
Chas. H. Modes	1	
Robert F. Ferguson	1	
W. B. Kerr	1	
A. Malinovszky	1	
W. E. Buck	1	
A. S. Watts	1	
C. Forrest Tefft	1	
Ruth E. Canfield	1	
Alice A. Ayars	1	

	Personal	Corporation
J. M. Manor	1	
Karl Türk	1	
Alexander Silverman	1	
Wilbur F. Brown	1	
Office	8	3
Total	37	3

Status of Membership

March 14, 1923	1710	223
Resigned	9	0
	1701	223
New Members	37	3
April 14, 1923	1738	226

NEW MEMBERS FROM MARCH 14, 1923, TO APRIL 14, 1923

ASSOCIATE

Ammon, Millard G., 53 Euclid Ave., Columbus, Ohio, Student, O. S. U.

Armstrong, Robert Hood, Watsontown, Pa., Ceramic Engineer, Fiske & Co., Inc., Watsontown, Pa.

Ayars, Alice A., 1914 West Boulevard, Cleveland, Ohio. Glazing and Firing Pottery for Cleveland High School.

Bradley, Richard S., 105 Daniel St., Champaign, Ill., Student, Univ. of Ill.

Briggs, Wm. B., 281 Margueritta St., Toronto, Ont., Can., Supt. Enameling and Mixing Dept., Standard Sanitary Mfg. Co., Toronto, Ont., Can.

Carter, John D., 121 S. 3d St., Philadelphia, Pa., Philadelphia Quartz Co.

Clark, H. E., Room 409 Whitney Bldg., 310 Main St., Springfield, Mass., Treas. & Gen. Mgr., The Springfield Brick Co.

Deeds, Floyd D., Grant St., Newell, W. Va., Ceramic Asst., E. M. Knowles China Co.

Douglas, Freeman S., Box 108, East Liverpool, Ohio., Asst. Engr., The Babcock & Wilcox Co.

Eccles, J. H., 371 Aqueduct St., Montreal, Can., Canada Firebrick Co., Ltd.

Ely, William Grosvenor, Jr., Y. M. C. A., Kokomo, Ind., Asst. Supt. Pittsburgh Plate Glass Co.

Fliedner, Helen M., 1971 West 99th St., Cleveland, O., Supervisor of Art.

Giacomini, Clarence D., 770 Osage St., Leavenworth, Kan., Head of Enameling Dept., Great Western Stove Co.

Harrison, Harold C., 791 Oak St., Columbus, Ohio, Student, O. S. U.

Herger, Howard C., % Pierce Glass Co., Port Allegany, Pa., Secy. and Chem.

Jenkins, S. Mark, 420 Bulkley Bldg., Cleveland, Ohio, Dist. Mgr. Cleveland District, Celite Products Co.

Ladoo, Raymond B., 1448 Girard St., N. W., Washington, D. C., Mineral Technologist, Bur. of Mines, Washington, D. C.

Leibowitz, Samuel, Haines and Russel St., Baltimore, Md., Mgr. Maryland Chemical Co.

Manley, Rowland, 3820 Cornelia Ave., Chicago, Ill., Ceramic Engr., Peoples Gas Light and Coke Co.

Matlack, W. Fred, Golding Sons Co., Trenton, N. J., Mgr. Trenton & Wilmington Depts.

Meadows, A., 5509 Brooklyn Ave., Detroit, Mich., Chief Engr., The Detroit Vapor Stove Co.

Mountford, Enoch, 315 Ardmore Ave., Trenton, N. J., Gen. Mgr., Anchor Pottery, Trenton, N. J.

Owen, C. E., Box 108, East Liverpool, Ohio, Ceramist, The Babcock and Wilcox Co.

Platts, Matthew, Box 52, Millrae, California, Factory Mgr., West Coast Porcelain Mfrs.

Pfeiffer, Wilbur H., 814 West Main St., Urbana, Ill., Student, Univ. of Ill.

Pole, Gordon R., Mellon Institute, Pittsburgh, Pa., Asst. Fellow.

Reif, Richard E., 706 Gregory Place, Urbana, Ill., Student, Univ. of Ill.

Seasholtz, Ralph Edgar, 1236 Hill Road, Reading, Pa., Foreman with J. M. Seasholtz, Inc.

Schofield, Perlee W., Chicago Heights, Ill., Pres. & Gen. Mgr., Chicago Heights Bottle Co.

Skinner, Sherrod E., 699 Stanley St., New Britain, Conn., Mechanical Engr., Landers Frary & Clark.

Smith, Albert J., 111 Richardson St., Syracuse, N. Y., Supt. Iroquois China Co.

Tracy, Ray C., % Washington Iron Works, Los Angeles, Calif., Foreman, Enameling Dept.

Vaughn, Haydn E., 7107 Mt. Vernon St., Pittsburgh, Pa., Student, Univ. of Pitts.

Walworth, Chester Alexander, % Libbey-Owens Sheet Glass Co., Charleston, W. Va., Chemist.

White, Francis Guy, University Club, St. Louis, Mo.

Yang, S. D., Box 46, University Station, Urbana, Ill., Student, Univ. of Ill.

Wu, Tso Ming, 160 W. 9th Ave., Columbus, Ohio, Student, O. S. U.

CORPORATIONS

American Blower Company, 6004 Russell St., Detroit, Mich., Thomas Chester.

Karr Range Co., Belleville, Ill., T. A. Stoelzle, Gen. Mgr.

The River & Feldspar Company, P. O. Box 581, Middletown, Conn., A. C. Postley, Secy. & Treas.

WHO'S WHERE IN THE AMERICAN CERAMIC SOCIETY

Samuel P. Adams is living at 316 South Grove Street, Oak Park, Ill.

Russell E. Arnold who has been at Derry, Pa. has been transferred to the Research Building, Westinghouse Elec. and Mfg. Co., at East Pittsburgh, Pa.

Bertram L. Cassady has moved from Chippewa Lake, Ohio to Tulsa, Okla.

Arthur L. Donnenwirth who has been with the Jeffery-Dewitt Insulator Co., at Kenova, W. Va., is now with the Westinghouse High Voltage Insulator Co., at Derry, Pa.

Karl L. Ford has changed his address to 3156 18th Street, N. W., Washington, D. C.

Harry D. Foster, also of the Bureau of Standards in Washington, has moved to 4310 4th Street, N. W., Washington, D. C.

R. B. Gilmore until recently located at the Ceramic Experiment Station, U. S. Bureau of Mines, Columbus, has accepted a position with the Laclede-Christy Clay Products Company, St Louis, Mo.

Arthur F. Gorton, formerly with the National Malleable Castings Co., at Cleveland has accepted a position with the Western Electric Company, Hawthorne Station, Chicago, Ill.

C. A. Hahn has left the Parker Russell Mfg. Co. and is now with the Missouri Fire Brick Co., Security Bldg., St. Louis, Mo.

Marsden H. Hunt is now with the Western Electric Company, First National Bank Building, San Francisco, Cal.

Robert W. Jones, geologist at Catskill, N. Y., is living at 15 New St.

Hobart M. Kraner who was formerly with the Ceramic Experiment Station, U. S. Bureau of Mines, Columbus, is now with the A. C. Spark Plug Co., at Flint, Mich.

J. L. Laird has affiliated himself with the Research Department of the Ford Motor Co., and is living at 25 Francis Street, Dearborn, Mich.

T. Poole Maynard is located at 1526 Hurt Bldg., Atlanta, Ga.

J. C. Montgomery, recently of the Limoges China Co., Sebring, Ohio is with the Atlas China Co., at Niles, Ohio.

C. P. Nye is now with the Conemaugh Iron Works, Blairsville, Pa. Mr. Nye was formerly manager of the Richmond Radiator Company of Uniontown, Pa.

Harold H. Preston lives at 415 Dithridge Street, Pittsburgh, Pa.

John Rhead is with the Sanitary Earthenware Specialty Co., of Columbus, Ohio.

Fred H. Robertson writes that he has moved from Los Angeles, Cal., to 204 West Tomita Street, Glendale, Cal.

Oscar Scherer is now at 212 4th Ave., North Nashville, Tenn.

T. A. Shegog has removed recently from New York City to 345 Indiana Ave., W., Sebring, Ohio.

Charles L. Stamm is living at 29 South 12th Street, Mt. Vernon, N. Y.

Jack Holmes Waggoner, late of the Canadian Libbey Owens Sheet Glass Co., Ltd., has moved to Topeka, Kans., Route 27.

C. P. Wood has been transferred from the Philadelphia office of Lockwood, Greene and Co., to 101 Park Ave., New York City.

Y. Y. Wong of the Chen Kwong Co., is now at 237 Des Voeux Road, Hong Kong, China.

NO ADDRESSES

Information regarding the addresses of any of the following members will be received with thanks by the Secretary's office. A few of the names published in the December issue of the *Bulletin* have been located.

G. V. Baker, Penn Feldspar Co., Barnard, N. Y.

Earl A. Bickel, Postville Clay Products Co., Postville, Iowa.

J. P. Callaghan, Teaque Hotel, Montgomery, Ala.

C. V. Cameron, Whiting-Mead Commercial Co., 2035 E. Vernon Ave., Los Angeles, Cal.

Homer T. Darlington, Box 736, Natrona, Pa.

Charles S. Dolley, Keramoid Mfg. Co., Fort Madison, Iowa.

Koji Fujioka, Shofu Porcelain Mfg. Co., Kyoto, Japan.

John L. Greenwood, Lehigh Sewer Pipe and Tile Co., Lehigh, Iowa.

S. B. Henshaw, Libbey-Owens Sheet Glass Co., Charleston, W. Va.

Sidney H. Ivery, 4432 Gibson Ave., St. Louis, Mo.

William J. Johnson, 4148 Langland St., Cincinnati, Ohio.

Y. Kitamura, Shofu Kogo Kafushiki Kaisha, Kyoto, Japan.

J. M. Knote, Mines Dept., L. S. Corporation, Sault Ste. Marie, Ont., Canada.

Leon W. Mitchell, Rock Island, Ill.

Knud Y. Chr. Moller, 4956 McPherson Ave., St. Louis, Mo.

K. Okura, 84 Kobayashi-Cho, Nagoya, Japan.

W. Pendrup, Coonley Mfg. Co., Cicero, Ill.
H. M. Pulsifer, Manhattan Bldg., Chicago, Illinois.
Nugent A. Ragland, 1280 West Adams St., Los Angeles, Cal.
Tefft, T. Dwight.
J. E. Thompson, 2507 Townsend Ave., Detroit, Mich.
A. L. Van Moore, American Photo. Glass and Export Co., New Eagle, Pa.
William J. Vodick, 1733 Lake Ave., Wilmette, Ill.

OFFICIAL PERSONNEL OF THE ENAMEL DIVISION

Officers

H. F. Staley, *Chairman*
Metal and Thermit Corp.
120 Broadway, New York City
R. R. Danielson, Secretary
Beaver Enameling Co.
Ellwood City, Pa.

Councilors

H. C. Beasley
Coonley Mfg. Co.
Cicero, Ill.
W. C. Lindemann
A. J. Lindemann & Hoverson Co.
Milwaukee, Wis.
M. E. Manson
Rundle Mfg. Co.
Milwaukee, Wis.
D. F. Riess
The Vollrath Co.
Sheboygan, Wis

Standing Committees

Research

R. R. Danielson, *Chairman*
Beaver Enameling Co.
Ellwood City, Pa.

SHEET IRON AND STEEL

Adams, L. A.
Mansfield Vitreous Enameling Co.
Mansfield, Ohio
Aupperle, J. A.
American Rolling Mill Co.
Middletown, Ohio
Bardush, J. F.
Grand Rapids Refrigerator Co.
Grand Rapids, Mich.
Blackburn, C. A.
Cleveland Metal Products Co.
Cleveland, Ohio
Buck, D. M.
American Sheet & Tin Plate Co.
Pittsburgh, Pa.
Dimmick, R. B.
United Alloy Steel Corp.
Canton, Ohio
Richardson, Ernest
Ingram-Richardson Co.
Beaver Falls, Pa.

CAST IRON

Jackson, W. L.
Wolff Mfg. Co.
111 S. Kilpatrick Ave.
Chicago, Ill.
Kahn, B. B.
Estate Stove Co.
Hamilton, Ohio
Manson, M. E.
Rundle Mfg. Co.
Milwaukee, Wis.
Reed, J. C.
Standard Sanitary Mfg. Co.
Pittsburgh, Pa.
Rice, B. A.
Elyria Enameled Products Co.
Elyria, Ohio

Standardization of Tests

E. P. Poste, *Chairman*
513 Park Ave.
Elyria, Ohio
Arnold, H. C.
A. D. Little, Inc.
4020 McRee Ave.
St. Louis, Mo.
Cooke, R. D.
Columbian Stamping & Enameling Co.
Terre Haute, Ind.
Frost, L. J.
Vitreous Enameling Co.
Box 67, Station D
Cleveland, Ohio
Geisinger, E. E.
The Pfaudler Co.
Rochester, N. Y.
Gifford, M. C.
Chicago Hardware Foundry Co.
Chicago, Ill.
Manson, M. E.
Rundle Mfg. Co.
Milwaukee, Wis.
Storey, O. W.
C. F. Burgess Laboratories
Madison, Wis.

Data

T. D. Hartshorn, *Chairman*
U. S. Bureau of Standards
Kensington, Md.
Arnold, H. C.
A. D. Little, Inc.
4020 McRee Ave.
St. Louis, Mo.
Hansen, J. E.
Mellon Institute
Pittsburgh, Pa.

Standardization of Products

D. F. Riess, *Chairman*
The Vollrath Co.
Sheboygan, Wis.
Blackburn, C. A.
Cleveland Metal Products Co.
Cleveland, Ohio
Cox, H. N.
Central Stamping Co.
48 Woodland Ave.
Glen Ridge, N. J.
DeWitt, Bert G.
Belmont Stamping Co.
New Philadelphia, Ohio
Keehn, C. C.
Lisk Mfg. Co.
Canandaigua, N. Y.

Sweely, B. T.
Baltimore Enamel & Novelty Co.
Box 34
Baltimore, Md.

Membership

Karl Türk, *Chairman*
116 W. Hamilton Ave.
Baltimore, Md.
Dwyer, Emmet
Michigan Stove Co.
Detroit, Mich.
Hansen, J. E.
Mellon Institute
Pittsburgh, Pa.
Hodek, F. E.
General Porcelain Enameling Co.
Chicago, Ill.
Jaeger, F. G.
Superior Enameled Products Co.
10th & Mullanphy Sts.
St. Louis, Mo.
Landrum, R. D.
Vitreous Enameling Co.
Grant Ave.
Cleveland, Ohio
Roadhouse, Robert
Benjamin Electric Co.
Des Plaines, Ill.
Smoot, C. E.
American Enameling & Stamping Co.
1900 Santa Fé Ave.
Los Angeles, Cal.

Special Committees

Enameling Furnaces for Sheet Metal Wares

Sweely, B. T., *Chairman*
Baltimore Enamel & Novelty Co.
Baltimore, Md.
Agge, Franklin
Republic Metalware Co.
Buffalo, N. Y.
Bittner, A. G.
National Enameling & Stamping Co.
Box 1400, Central Sta.
St. Louis, Mo.
Blackburn, C. A.
Cleveland Metal Products Co.
Cleveland, Ohio
Clarke, A. E.
Benjamin Electric Co.
Des Plaines, Ill.
Cox, H. N.
48 Woodland Ave.
Glen Ridge, N. J.
De Witt, Bert G.
Belmont Stamping Co.
New Philadelphia, Ohio
Geuder, George
38 15th Ave.
Milwaukee, Wis.
Hogenson, Wm.
Chicago Vitreous Enameling Co.
1421 S. 55th St.
Cicero, Ill.
Sanders, J. W.
U. S. Stamping Co.
Moundsville, West Virginia
Swift, Geo. C.
Enamel Products Co.
2029 E. 115th St.
Cleveland, Ohio
Taylor, Royal
Canton Stamping & Enameling Co.
707 12th St. N. W.
Canton, Ohio
Türk, Karl
116 W. Hamilton Ave.
Baltimore, Md.
Vollrath, J. C.
The Vollrath Co.
Sheboygan, Wis.

Enameling Furnaces for Sanitary Wares

Mahoney, Frank B., *Chairman*
Crane Enamel Ware Co.
Chattanooga, Tenn.
Arrott, A. J.
U. S. Sanitary Mfg. Co.
Pittsburgh, Pa.
Bowman, W. J.
Trenton Fire Clay & Porcelain Co.
Trenton, N. J.
Barnes, T. R.
Barnes Mfg. Co.
Mansfield, Ohio
Ebinger, Jr., D. H.
Ebinger Sanitary Mfg. Co.
735 Linwood Ave.
Columbus, Ohio
Kelley, J. A.
Iron City Sanitary Mfg. Co.
1514 Oliver Bldg.
Pittsburgh, Pa.
Kohler, W. J.
Kohler Co.
Kohler, Wis.
Ludlum, B. A.
Union Sanitary Works
Noblesville, Ind.
Manson, M. E.
Rundle Mfg. Co.
Milwaukee, Wis.
Nye, C. P.
Conemaugh Iron Works
Blairsville, Pa.
Tafel, Theodore, Jr.
Standard Sanitary Mfg. Co.
551 Preble Ave., N. S.
Pittsburgh, Pa.
Wassman, L. G.
Wolff Mfg. Co.
3320 Diversy Ave.
Chicago, Ill.

Enameling Furnaces for Wet Enamel for Cast Iron

Lindemann, W. C., *Chairman*
A. J. Lindemann & Hoverson Co.
Milwaukee, Wis.
Adams, L. A.
Mansfield Vitreous Enameling Co.
Mansfield, Ohio
Bridge, L. D.
Bridge & Beach Mfg. Co.
St. Louis, Mo.
Coulston, E. V.
Rock Island Stove Co.
Rock Island, Illinois
Cushman, H. D.
819 Finance Bldg.
Cleveland, Ohio
Luepke, Emil
Quick Meal Stove Co.
St. Louis, Mo.
Munroe, L. J.
912 Colborne St.
London, Ont., Canada
Roberts, F. G.
Porcelain Enamel & Mfg. Co.
Baltimore, Md.
Walton, W. E.
American Stove Co.
St. Louis, Mo.
Wells, R. D.
Floyd-Wells Co.
Royersford, Pa.

Smelting Furnaces and Smelter Linings

Manson, M. E., *Chairman*
Rundle Mfg. Co.
Milwaukee, Wis.
Bittner, A. G.
National Enameling & Stamping Co.
Central Sta., Box 1400
St. Louis, Mo.

Davis, H. E.
Northwestern Terra Cotta Co
Chicago, Ill.
Tafel, Theodore Jr.
Standard Sanitary Mfg. Co.
551 Preble Ave., N. S.
Pittsburgh, Pa.
Wassman, L. G.
Wolff Mfg. Co.
3320 Diversy Ave.
Chicago, Ill.
Williams, W. G.
Coonley Mfg. Co.
Cicero, Ill.

DRY GRINDING MILLS AND LININGS

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DR. NAVIAS RECEIVES APPOINTMENT

Dr. Louis Navias has been appointed special expert in ceramics and optical glass by the United States Tariff Commission, the work to be carried on under the direction of Dr. Karl Langenbeck. Dr. Navias received his degree of doctor of philosophy in ceramics in January from the University of Illinois. His graduate work was completed under the direction of Dr. E. W. Washburn.

OBITUARIES

News of the death of Dr. C. W. Waggoner, head of the department of physics at the University of West Virginia, Morgantown, W. Va., has been received in the Secretary's office. Dr. Waggoner was thrown from his horse, sustaining a fractured skull. At the time of his death, October, 1922, he was on a year's leave of absence from the University doing research work in connection with the United States Plate Glass Company at Shreveport, La.

Chauncey William Waggoner was born in Rock Bride, Ohio in 1881. He received the degree of M.S.E.E. from Ohio University in 1904, A.M. degree from Cornell in 1905 and Ph.D. from Cornell in 1909. Since 1909 Dr. Waggoner had been professor of Physics at the University of West Virginia. Through his notable work on light, magnetism and the manufacture of glass he became well known in scientific circles and his writings have appeared frequently in scientific journals of the country. He was assistant commissioner of weights and measures of West Virginia, consulting engineer for a number of glass manufacturing plants and among scientific societies he was a member of Sigma Xi, the AMERICAN CERAMIC SOCIETY and the American Association for the Advancement of Science.

His death is greatly to be regretted and he will be missed from his place as a man of science as well as a useful citizen.

Nathaniel Wright Lord, Jr.

Nathaniel Wright Lord, Jr. died on April 8, 1923 at Mt. Carmel Hospital, Columbus, Ohio, after an illness of three months' duration. Mr. Lord, who was twenty-three years of age was a third-year student in the department of Ceramic Engineering at Ohio State University. During the years 1920 and 1921 he was employed by the American Encaustic Tiling Company at Zanesville, Ohio. In 1918 Mr. Lord was a member of the Student Army Training Corps at Ohio State University. He is survived by his mother, Mrs. N. W Lord of Columbus, Ohio and two brothers, James O. Lord, instructor in metallurgy, and Leland L. Lord, a first year student in the College of Arts,

both at O. S. U. He was a son of the late Prof. N. W. Lord of Ohio State University. For the past two years, Mr. Lord had been an associate member of the AMERICAN CERAMIC SOCIETY.

NOTES AND NEWS

RESEARCH ORGANIZATION OF THE NATIONAL LIME ASSOCIATION

BY M. E. HOLMES

Within recent years the uses of lime in chemistry, construction and agriculture have taken on such an increasingly technical aspect that the lime industry today is one of our highly technical industries especially in regard to chemical engineering. The use of lime in agriculture involves a detailed application of the principles of agronomy and chemistry. The use of lime in construction has ceased to be the rule of thumb proposition that it was in the past and demands are now being made for scientifically produced lime products and technically controlled building operations. The use of lime for chemical purposes which has grown with remarkable rapidity during recent years has made new demands upon the lime industry for technical information regarding the fundamental properties and utility of lime and the many details of its adaptability to the varied and numerous chemical functions in modern manufacturing and sanitary engineering processes.

The lime industry has met these demands by establishing a research organization with headquarters at 918 G Street, N. W., Washington, D. C. The lime industry recognizes that all the lime producing companies have a common interest in furthering and developing the knowledge of lime and its uses and also recognizes that this work can best be done by a common central research organization instead of each company attempting to do it individually in which case there would be inadequate facilities and wasteful duplication.

MAJOR E. HOLMES, PH.D., Chemical Director, National Lime Association.

The research organization of the National Lime Association consists of a central laboratory in Washington, and fellowships at Universities and government laboratories under the direction of Dr. M. E. Holmes, Chemical Director. In addition, coöperative research relations are maintained with the laboratories of industrial plants, universities and other research agencies.

The central laboratory at Washington is concentrating on the fundamental properties of commercial limes. Samples of limes from nearly every lime plant in the country are being studied with the object of getting as complete information as possible on all their fundamental properties, such as density, porosity, characteristics in suspensions, chemical reactivity toward solids, solutions and gases, etc. These data have a bearing upon practically every industrial use of lime.

Other problems under way in the central laboratory are the development of new uses for lime, a study of improvements in the quick-setting properties of lime mortar, the

preparation of ready mixed plaster, the study of lime as a causticizing agent, the development of improved aqueous lime paints and the solving of problems encountered by the users of lime.

The Association maintains a fellowship at Ohio State University where Prof. J. R. Withrow is coöperating in directing an extensive study of the burning of various typical limestones under various conditions of time and temperature to determine the effect of these conditions upon the properties of the lime for construction and chemical purposes.

The Association maintains a fellowship at Indiana University where Prof. F. C. Mathers is coöperating in directing research on the effect of admixtures upon the hardening properties of lime mortar, the manufacture of special lime products, such as peroxides, the study of lime as a dehydrating agent, polishing agent, etc.

The Association also maintains a fellowship at the Bureau of Standards at Washington, D. C., where Mr. Warren E. Emley is coöperating in the direction of work designed to improve the uses of lime primarily for construction purposes. This work is primarily along the line of improved lime products and improving the use of lime products. Unlike the other research activities of the Association the work at the Bureau of Standards under the direction of Mr. Emley has been in progress a number of years and the valuable results that have been achieved are well known. The agricultural department of the Association also maintains a fellowship at the University of Tennessee.

The Association will also establish at least one more university fellowship to work upon problems in the chemical and construction uses of lime but the place has not been decided upon at this writing.

Coöperative research relations are maintained with several universities, especially Cornell and Massachusetts Institute of Technology, which have departments interested in lime research for their post-graduate students, whereby they render valuable service to the lime industry and at the same time the arrangement provides the researcher with a most fertile field of study.

The main idea back of the research organization is service, service to the user of lime whereby the use of lime can be extended and enlarged upon a thoroughly sound and scientific basis. The results of the research will be given the widest possible publicity in the form of magazine articles, and bulletins and will serve as the background for the various activities of the association, such as standardization and field promotion work.

ENGINEERS, SCIENTISTS, AND EDITORS PLAN TO STANDARDIZE SYMBOLS AND ABBREVIATIONS

A recent conference held in New York City under the auspices of the American Engineering Standards Committee revealed a sentiment among engineers, scientists, government officials, business paper editors, and industrial executives, emphatically in favor of the unification of technical and scientific abbreviations and symbols.

It was agreed on all sides that the standardization of abbreviations and symbols would result in inestimable mental economies. The present situation with respect to the use of abbreviations and symbols in engineering, scientific, and other technical fields is comparable to a language which has degenerated into a multiplicity of dialects each of which has to be translated for the users of the others. Abbreviations and symbols constitute an ever growing and important part of the language of engineers, scientists, industrial editors, and other technical men. The use of one symbol or abbreviation for several different terms and the use of several different symbols or abbreviations for one meaning are, however, at present causing a great deal of confusion, misunderstanding, and, often, serious errors.

The conference was called upon requests from the American Institute of Electrical

Engineers, the American Society of Mechanical Engineers, and the Association of Edison Illuminating Companies, to consider abbreviations and symbols, but after some discussion of the subject it was thought desirable to include as a part of the project, the graphical symbols which are used in engineering drawings, diagrams, and the like, for representing instruments and apparatus and components of them.

It was agreed that the coöperation of foreign standardizing bodies should be sought, in the development of the work. The importance of international uniformity in symbols is great on account of the international character of much engineering and scientific work, and the importance of reference books and periodicals in foreign languages.

The work will go forward under a committee organization developed in accordance with the rules and procedure of the American Engineering Standards Committee.

THE CERAMIC SOCIETY

By James A. Audley

The volumes of the *Transactions* of the North Staffordshire Ceramic Society, the precursor of the Ceramic Society in England, contain no official record of the foundation of the Society or of its earliest meetings. The first volume relates to proceedings in the session 1901–2, and it was somewhat hastily assumed that this must have corresponded with the first year of the Society's existence. Accordingly, in hurrying to complete and dispatch the brief notice for insertion in the *Journal of the American Ceramic Society*, January, 1923, the Society was stated to have been established in 1901. Some doubt having arisen, the writer determined to make a careful search in contemporary publications of 1900 and 1901, and definitely ascertained that the actual formation of the Society took place in the autumn of 1900. Several meetings were held, but, apart from summarized reports in the press during this time, no authoritative account of the work of the first session was published, the first volume of the *Transactions* issued being concerned with the second session.

Dr. J. W. Mellor (right) and Sir Wm. J. Jones, K.B.E. (left) at Mr. Odelberg's house at Gustafsberg.

It should have been mentioned that Mr. Henry Watkin was the second president succeeding Mr. W. Burton and preceding Mr. B. Moore.

ASSOCIATION OF CENTENARY FIRMS OF THE UNITED STATES

This is an association of firms which are now being managed by direct descendants in the male line from the founders of the concerns one hundred years old. The present roster contains eighty-one concerns.

Mr. Burnet Landreth of the D. Landreth Seed Company, Bristol, Pa., wishes to learn of the ceramic concerns which have been managed continuously for one hundred years by direct male descendants of the founders of the business.

Ten of the concerns on the roster of the Association of Centenary Firms have so

changed the management that none of the direct descendants of the founder remain in the administration of the firms affairs although for one hundred years their management has been directed by direct male descendants.

It is estimated that probably there are not a half dozen concerns in addition to the eighty-one establishments in the United States that are eligible for membership.

A. H. Hews and Co., Cambridge, Mass., and Whitney Glass Works, Glassboro, N. J., are the only centenarians listed from the ceramic industries. Do you know of others?

NOTES FROM THE U. S. BUREAU OF MINES

Oxidation of Ceramic Wares during Firing

A study of the chemical and physical changes taking place in clay bodies during firing is under way at the ceramic experiment station of the Bureau of Mines, Columbus, Ohio, and will be continued during the coming year since a better understanding of the reactions taking place in a ceramic kiln is essential before many of the problems confronting the ceramic industry can be solved.

Much fundamental information of a laboratory character has been obtained as to the oxidation of iron, sulphur, and organic material at all stages in the firing. A paper by Bole and Jackson containing data on the rate of evolution of SO_2–SO_3–H_2O–CO_2 from a fire-clay body at varying temperatures in an atmosphere of oxygen is in course of preparation. This is the first of a series of papers to appear giving results of this work. A study of the effect of varying the bathing atmosphere within kiln limits will now be made. It is proposed later to investigate the problem along similar lines on industrial kilns.

After sufficient fundamental data has been obtained, it is proposed to investigate the several special problems which have arisen in the field in connection with the cooperative work with the four Heavy Clay Products' Associations. These problems include among others (*a*) the possibility of removing sulphur fumes from kiln gases so that they may be run directly through dryers, (*b*) the cause and prevention of red core in buff face brick, (*c*) an explanation of the so-called "blue smoke" and its influence on oxidation, (*d*) the cause and prevention of slabbing or popping of ware from siderite bearing clays.

Dolomite and Magnesite Refractories

Before the best results can be obtained from dolomite as a refractory, certain fundamental data not yet available must be at hand. Since previous work has indicated that highly aluminous fluxes together with a small percentage of the sesqui oxide of iron are the most desirable for the dead burning of dolomite, the problem is being studied systematically at the Ceramic experiment station of the Bureau of Mines.

Phase rule diagrams for three component systems are being worked out in order to find the non-slaking areas using varying percentages of the flux. The system has been completed using 10% flux and it is planned to continue the work using 5–15–20 and 25% flux. The aluminous flux used is a bauxitic clay and the iron oxide may or may not have to be added depending upon the per cent present in the clay.

The material used up to the present has been a dense Niagara dolomite, but a highly crystalline stone such as that obtained near Gouverneur, N. Y. will later be tried out. Using the information obtained from the one diagram already completed, some good bricks have been made but much more is anticipated after the whole field has been covered.

Investigation of the System ZrO_2–TiO_2–SiO_2

The metallurgical field is constantly demanding a refractory material which will stand up under more severe heat conditions, states the Bureau of Mines. There are many other demands on a refractory for specific utilization, but it must be primarily a material with a high softening point. The refractory further must not vary widely in acidity or basicity from the slag with which it comes in contact. With these considerations together with that of economy in view, it is apparent that there are only a very few materials available for the purpose. It is proposed by the Bureau of Mines therefore to start work on the system ZrO_2–Al_2O_3–SiO_2 with the object in view of obtaining fundamental data in regard to refractories, abrasives and quartz glass. The purification of the ZrO_2 has already been completed. An induction furnace in which temperatures up to 3000°C can be attained is being installed for this and similar work at the Ceramic experiment station at Columbus, Ohio.

CLOSER COÖPERATION BETWEEN GOVERNMENT AND INDUSTRY IN STANDARDIZATION WORK

Another important step toward the elimination of differences between specifications for government purchases and specifications for similar materials produced for the general commercial market, was taken at the March meeting of the American Engineering Standards Committee, when it was voted to accede to the suggestion of the Federal Specifications Board that the A.E.S.C. submit to the Board for its information all standards which are being considered by the A.E.S.C. for approval. In cases where standards before the A.E.S.C. prove also of interest to any government department, the matter of their formal approval as government standards may then be considered by the Federal Specifications Board.

The Federal Board has for some time used the machinery of the American Engineering Standards Committee to bring its specifications into harmony with the best commercial practice, thereby broadening its source of supply and lessening the cost of production. Under this arrangement twenty-two specifications for government purchases have already been submitted to industry for criticism in advance of their adoption by the Federal Specifications Board.

Through the presence of seven departments of the federal government in the membership of the American Engineering Standards Committee the government has participated in the formulation of industrial standards. Now industry has an opportunity to participate, as an advisor, in the formulation of government standards, thus minimizing the possibilities of duplicated effort in the field of standardization.

MINUTES OF THE ELECTRICAL PORCELAIN SECTION, ASSOCIATED MANUFACTURERS OF ELECTRICAL SUPPLIES

A regular meeting of the Electrical Porcelain Section of the Associated Manufacturers of Electrical Supplies was held at the Wm. Penn Hotel, Pittsburgh, Pa. on Wednesday, December 13th, 1922.

Invitations to attend the meeting were extended to every manufacturer of electrical porcelain, the object being to acquaint the entire industry with the advantages possible through association membership.

ROLL CALL

Brunt Porcelain Co.	Geo. F. Brunt
Cook Pottery Co.	Paul G. Duryea
Federal Porcelain Co.	R. G. Spencer
Hartford Faience Co.	F. L. Bishop
Imperial Porcelain Works	B. B. Dinsmore
Locke Insulator Mfg. Co.	B. A. Plimpton
Westinghouse Hi-Voltage Ins. Co.	Geo. I. Gilchrist
Star Porcelain Co.	F. F. Gardinor
R. Thomas & Sons Co.	J. E. Way
	H. R. Holmes

and by special invitation the following non members:

American Porcelain Co.	W. J. Curry
Colonial Insulator Co.	Jas. R. Hemphill
Carey Ohio Porcelain Co.	W. D. Wooley
Davidson Porcelain Co.	W. Davidson
Findlay Elec. Porcelain Co.	J. V. Patterson
General Porcelain Co.	W. S. Cook
Specialty Porcelain Works	J. W. Boch
Standard Porcelain Co.	Harry Yates
Summit Porcelain Co.	Anthony Comfort
Trumbull Elec. Mfg. Co.	J. M. Gilfillan
Trenle Porcelain Co.	G. A. Trenle
	H. W. Blake
Union Electrical Porcelain Works	J. Mackenzie
West Virginia Porcelain Co.	Dr. Ferrell

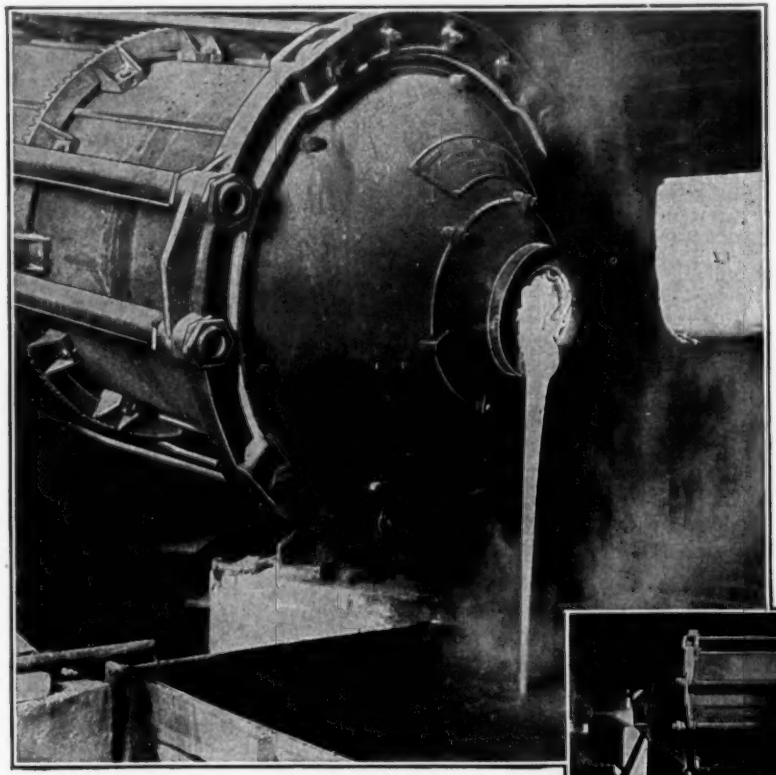
The meeting was called to order by the Chairman, Mr. J. E. Way at 10:30 A.M. Mr. Duryea explained briefly the call for the meeting after which the Chairman introduced Mr. S. L. Nicholson, President of the A.M.E.S. Mr. Nicholson who is also Chairman of the Electrical Manufacturers Council, reviewed the history of the Council, and described very clearly the procedure of its various committees in handling matters of vital interest to the Electrical Manufacturing industry. Among those especially mentioned was regulatory legislation and ordinances proposed by State and Municipal authorities affecting the electrical industry, and it was convincingly shown that when such proposals threaten the rights of Manufacturers of Electrical Supplies and Apparatus and are unjust in their application that the best means of defense is offered by the co-operative methods of the Association. This talk by Mr. Nicholson which is very briefly reported in these minutes occupied about two hours time and without question marked the meeting as the most interesting and instructive ever held by the Section. Acknowledgment was expressed by a rising vote of thanks. Mr. Duryea emphasized the fact that the machinery for handling all matters of general interest to the Porcelain Section requiring any action by the Council was in full operation and available to its members.

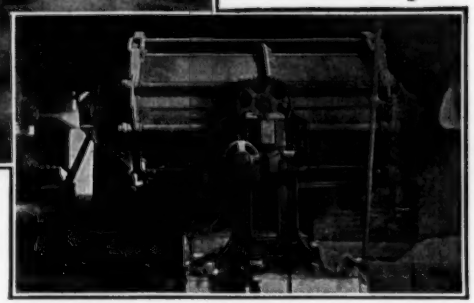
The expense of membership was explained and application blanks distributed. Applications for membership from The American Porcelain Company, The Summit Porcelain Company, Inc., The Trenle Porcelain Co. and the W. Virginia Porcelain Company were filed with the Secretary, and the discussion following the remarks of Mr. Nicholson encouraged the belief that other applications will result. The meeting adjourned for lunch at 1 P.M., after which the Section proceeded with the regular order of business.

CALENDAR OF CONVENTIONS

American Association of Engineers—Norfolk, Va., May 7 to 9.
American Dental Trade Association—Spring Lake, N. J., June, 1923
American Electrochemical Society—Commodore Hotel, N. Y., May 3, 4, 5.
American Face Brick Association—First Week in December, 1923.
American Face Brick Association (Southern Group)—West Baden, Ind., November, 1923.

American Gas Association—Atlantic City, Week of Oct. 15, 1923.
American Institute of Chemical Engineers—Wilmington, Del., June 20–23, 1923.
American Society of Mechanical Engineers—Montreal, Can., May 28–31.
American Society for Testing Materials—Chalfonte-Haddon Hall Hotel, Atlantic City, June 25, 1923.
American Zinc Institute—St. Louis, Mo., May 7 and 8, 1923.
Canadian Institute of Chemistry—Toronto, Can., May 29 to 31, 1923.
Chamber of Commerce of the United States of America—New York City, May 8–10, 1923.
Clay Products Association—Chicago, Ill., Third Tuesday in each month.
Dental Manufacturers' Club of the United States—Spring Lake, N. J., June, 1923.
Fire Underwriters' Association of the Northwest—Chicago, Ill., October 17–18, 1923.
Iron and Steel Institute (London)—House of the Institution of Civil Engineers, London, S. W. 1, May 10 and 11, 1923.
Manufacturing Chemists' Association—New York, June, 1923.
National Association of Manufacturers of the United States—Waldorf-Astoria Hotel, New York City, May 14 to 16, 1923.
National Association of Stove Manufacturers—Richmond, Va., May 9, 1923.
National Association of Window Glass Manufacturers—Place and date not determined.
National Board of Fire Underwriters—New York, May 24, 1923.
National Exposition of Chemical Industries (Ninth)—New York, Sept. 17 to 22, 1923.
National Foreign Trade Council—New Orleans, La., Postponed from April to May 2, 3 and 4.
National Gas Appliance Manufacturers' Exchange—Kansas City, Mo., May, 1923.
National Lime Association—Hotel Commodore, New York City, June 13 to 15, 1923.
National Paving Brick Manufacturers' Association, December, 1923.
National Symposium on Colloid Chemistry—University of Wisconsin, June 12 to 15, 1923.
Sanitary Potters' Association—Pittsburgh, Pa., Monthly Meetings.
Society of Chemical Industry (Canadian Section)—Toronto, Can., May 29 to 31, 1923.
Stoker Manufacturers' Association—May or June, 1923.
Society for Steel Treatment (Eastern Section)—Bethlehem, Pa., June 14 and 15, 1923.
Tile Manufacturers' Credit Association—Beaver Falls, Pa., Quarterly Meetings.





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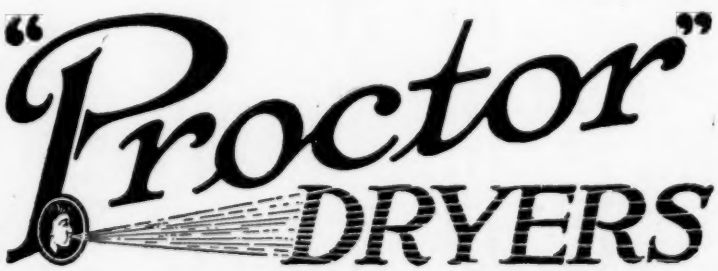

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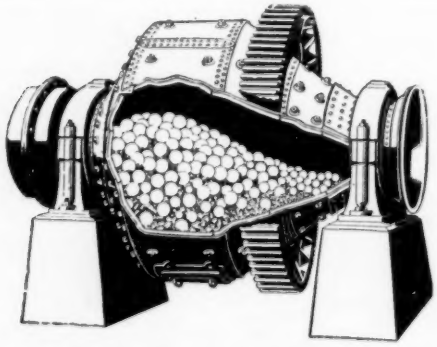

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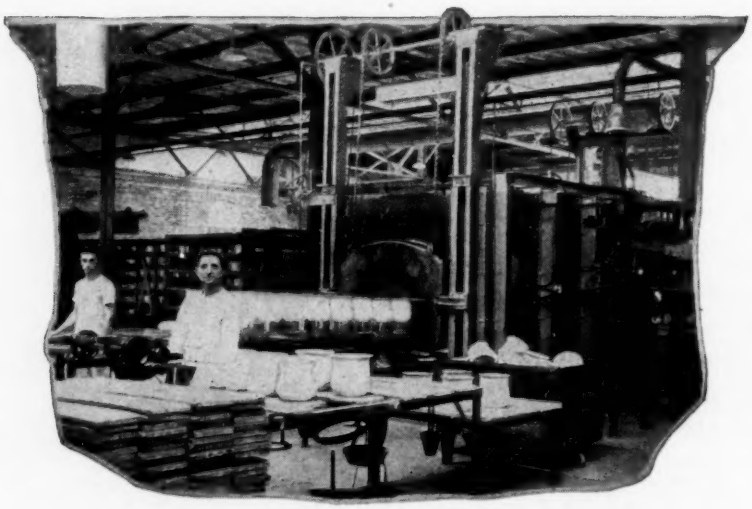

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	Page
American Rolling Mill	Back Cover
Bowman Coal Company	22
Brown Instrument Co.	18
Central of Georgia Railway Co.	25
Chambers Brothers Co.	22
Chicago Vitreous Enamel Product Co., The	1
Dominion Feldspar Corporation	17
Drakenfeld and Co., B. F.	10
Early, J. N.	16
Edgar Brothers Co.	22
Engelhard, Charles, Inc.	15
Ferro Enamel Supply Co.	22
General Electric Co.	12
Golding-Keene Co.	16
Hadfield-Penfield Steel Co.	17
Hardinge Co.	8
Harshaw, Fuller and Goodwin Co.	2
Journal of the Society of Glass Technology	20
Lindsay Light Co.	15
Madeira Hill & Company	23
McDanel Refractory Porcelain Co.	16
Metal & Thermit Corporation	21
Montgomery Porcelain Products Co.	17
Mueller Machine Co., Inc.	26
O'Brien and Fowler	16
Paper Makers Importing Co., (Inc.)	23
Parker-Russell Mining & Mfg. Co.	14
Pennsylvania Pulverizing Co.	19
Pennsylvania Salt Mfg. Co.	26
Philadelphia Drying Machinery Co.	18
Porcelain Enamel & Mfg. Co.,	Inside Back Cover
Proctor and Schwartz, Inc.	6
Roessler and Hasslacher Chemical Co.	Inside Front Cover
Seaboard Fuel Corporation	24
Surface Combustion Co.	14
United Alloy Steel Corp.	15
United Clay Mines Corp.	17
U. S. Smelting Furnace Co.	5
Vanderbilt Co., R. T.	4
Vitro Manufacturing Co.	19
Wilson-Maeulen Co., Inc.	16

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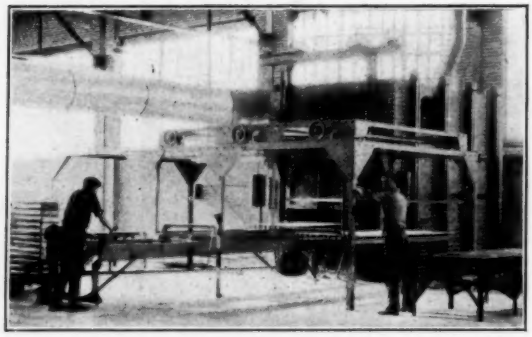

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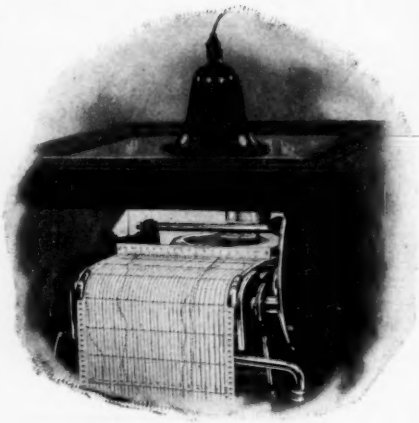

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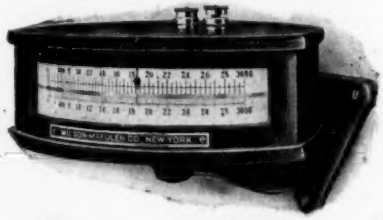

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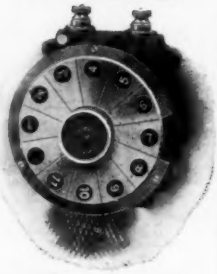

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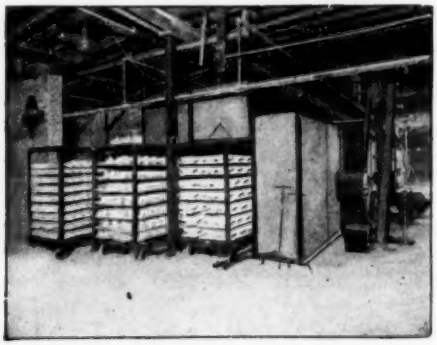

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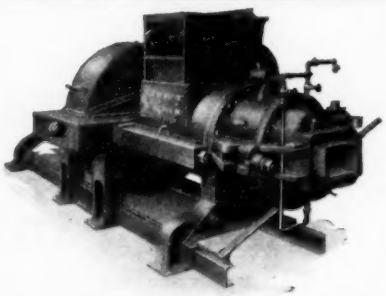

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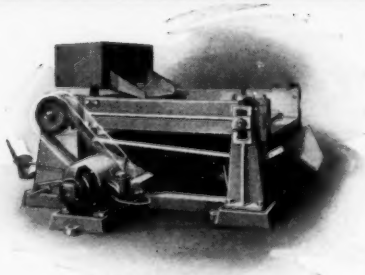

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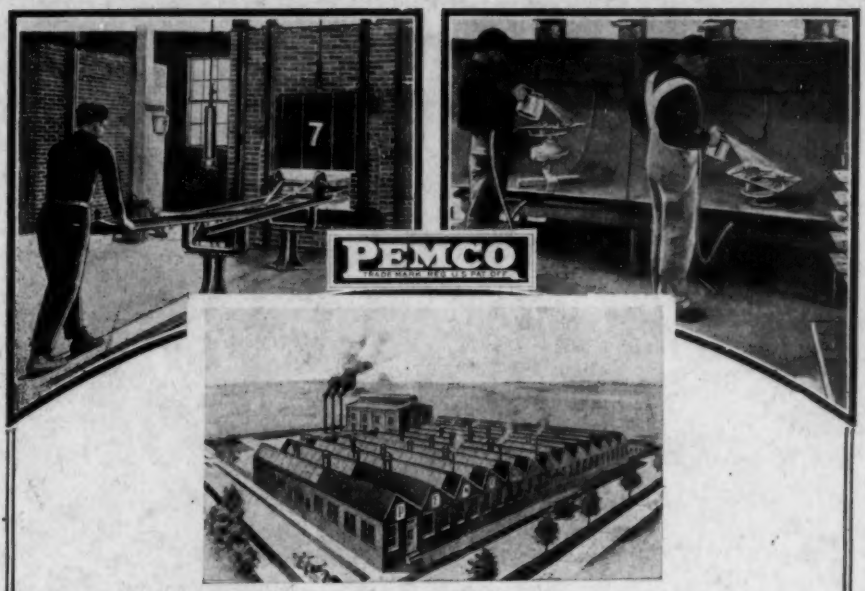

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